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THE ESPECIAL VALUE OF RESEARCH IN PURE CHEMISTRY[1]

MY colleague, Dr. Cattell, having considered the broad topic of the value to a democracy of research in pure science, I welcome the opportunity to take up for a few moments one of the subdivisions of his field, in order to point out somewhat more fully the especial importance of research in chemistry.

Let us, therefore, first pass rapidly in review a few of the contributions which chemistry has made or is now making to the health, happiness and material prosperity of our country, that we may be able more accurately to assess its value to the community, gain a better appreciation of the debt we owe it, and accord to it that position of high honor and dignity which is its just due.

In the reports of the Twelfth Census of the United States it is written that

> Probably no science has done so much as chemistry in revealing the hidden possibilities of the wastes and by-products of manufacturers. This science has been the most fruitful agent in the conversion of the refuse of manufacturing operations into products of industrial value. Her fairy wand has only to touch the most noisome substances, and the most ethereal essences, the most heavenly hues, the most delicious flavors and odors instantly rise as if by magic.

Whether this is a wholly overdrawn picture or not will appear in what follows.

Dealing with the ultimate constituents of our material universe, their combinations and transformations, it is chemistry that

[1] Address delivered on the occasion of the establishment of the Willard Gibbs Chair of Research in Pure Chemistry at the University of Pittsburgh, October 26, 1915.

has determined the composition of those substances which make up our own bodies, the earth upon which we live, the air we breathe, and the heavenly worlds beyond. Every particle of matter animate or inanimate acknowledges its sovereignty, for its laws govern alike the smelting of an ore, the manufacture of a complex dyestuff, or the mysterious vital processes of the living organism; and upon these laws our physical and our industrial life depend.

The transformation of the raw material into the finished product consists usually either in changing its external form, as in metal or wood working, weaving, and the like; or there is involved a chemical change, as in metallurgy, fermentation industries, the manufacture of cement, glass, soap, chemicals, etc. Our manufacturing processes are thus either mechanical or chemical, or a combination of the two.

Let us consider briefly the part chemistry plays in connection with some of the more important of these industries.

Turning first to the mineral world, it should be borne in mind that metallurgy is but one of the branches of engineering chemistry, whether it concerns the initial smelting operations or the production of new alloys for special purposes. The chemist is busily at work here, discovering ways of obtaining cheaply metals previously rare or expensive, thus inaugurating entirely new industries, as witness that of the manufacture of aluminium goods and alloys; analyzing raw materials (ore, coke, limestone, etc.), intermediate products (for many industrial operations are under chemical control at all points), and final products, such as the furnace gases, slags, and the like; improving old processes; devising new ones, particularly those which will render available low-grade or refractory ores; showing how wastes and by-products may be made valuable, the waste heat to raise steam or pre-heat the blast, and the slags for the production of cement and concrete, as fireproof packing for steam pipes, as ballast for railroad tracks, for macadamizing highways, for building purposes (as slag brick, slag blocks, etc.), or when rich in phosphorus (as those from the Thomas-Gilchrist process) for fertilizers. His success has been such in the iron industry, for example, as to lead Mr. James Douglas to remark that

> When all the volatile products of the blast furnace . . . are deprived of their heat-giving properties and their chemical constituents, and when the slags, as well as the metal, have returned their heat to man instead of to the atmosphere, and the slag itself has been turned into cement or some other useful article, it will be a question as to whether the pig iron is the principal object of manufacture or one of the by-products

It was the pioneer investigations of Bunsen and DeFaur which pointed the way for the use of furnace gases in many of the directions in which they are now so extensively employed. Another chemist, Sir Humphry Davy, by his invention of the safety lamp, has done more than any one else to protect the miner from accident and injury and, as you are well aware, the chemists of our government are now conducting experiments in this city to further reduce the loss of life and property incident to fires and explosions in mines.

Without the powerful explosives of the chemist, modern mining, modern warfare, and such great engineering projects as the Panama Canal, would all alike be impossible. After the precious metals have been extracted from their ores, it is the powder of the chemist which stands guard over them, as it does over all the accumulated wealth and property of this and other nations.

The chief source of our light, heat and power still remains the chemical combustion of some form of carbon, be it coal,

petroleum or natural gas; and chemistry again has shown how wastes may be avoided and by-products utilized. The great losses formerly permitted in the coking of coal are now being checked and the volatile products recovered, with the result that we shall soon be supplying all the benzole needed for our own home market. In the great illuminating gas industry, the by-products—ammonia water, tar and coke—are all made available by the chemist. The ammonia water is a leading source of ammonium compounds; and, as for the tar, the way in which this black, sticky, evil-smelling mass has been made to minister to the comfort and general prosperity of mankind constitutes one of the most brilliant chapters in the volume of modern scientific achievement. In the hands of the chemist, it has been transformed, as by magic, into a veritable Pandora's Box, from which may be produced healing drugs or the deadliest of poisons, delicious perfumes or the most disgusting of odors, dyestuffs of every hue of the rainbow or explosives powerful enough to annihilate this building in an instant—pleasure or pain, life or death, lie dormant there, awaiting the summons of the chemist. Then, too, chemistry has contributed the necessary mantles and filaments for modern incandescent lighting, whether by gas or by the electric current; and the calcium carbide from which acetylene gas is obtained.

A good example of the economy often accomplished by chemical research and discovery is afforded by the history of ultramarine. Many years ago when this pigment was made by powdering the mineral lapis lazuli, it sold for more than its weight in gold. Since the chemist has found how to make it from such cheap substances as kaolin, sodium sulfate and carbonate, charcoal, sulfur and rosin, the price is only a few cents per pound.

The value of our specie, upon which every commercial transaction rests, is decided by the chemist, while the green ink used in printing our banknotes, and to which they owe their name of "greenbacks," was invented by a former president of the American Chemical Society, Dr. T. Sterry Hunt.

The chemist lets nothing escape unsearched. The sweepings from the mints and from the shops and factories of workers in precious metals, as well as the water in which the workmen wash their hands, are all made to give up the gold or silver they contain. Even waste photographic solutions must disgorge their silver before they are permitted to escape.

Through the labors of the chemist, the pollution of our atmosphere by smoke, fumes, flue dust and noxious gases is being rapidly reduced; and the University of Pittsburgh is playing a prominent part in this campaign. Hundreds of thousands of tons of sulphur dioxide, formerly wasted in various quarters of the globe in polluting the atmosphere, are now, thanks to the discovery of the "contact process," annually converted into sulphuric acid, to be used for the manufacture of fertilizers, indigo and other valuable substances.

The purity of our water supply is a matter of serious concern to all of us, whether it is to be used for drinking purposes or for the industries, and both the chemist and the bacteriologist must pass upon it. The chief industrial use of water is for the generation of steam, and for this purpose the water must be free from large amounts of mineral salts, or the formation of boiler scale will proceed rapidly. So that, even in such a fundamental engineering operation as steam-power generation, the engineer must first consult the chemist as to the quality of the fuel and water he expects to use. The loss due to locomotive boiler scale alone in the United States has been esti-

mated as equivalent to fifteen million tons of coal per annum. Chemistry has also rendered yeoman service in reducing the pollution of our streams and coastal waters, by showing how many of these wastes may be converted into valuable commercial products, and more money be made in this way than by dumping them into the streams.

In those operations in which pure water is indispensable, the cost of impure water is the cost of purification, and it is to the chemist that the manufacturer must turn for instructions as to how this purification may be accomplished best. Impure water means additional cost of production, not only to the steam-power plant, as just mentioned, but also in paper-making, straw-board mills, brewing, distilling, ice manufacture, bleacheries, dye works, canning and pickle factories, creameries, abattoirs, packing-houses, factories for explosives, sugar, starch, glue, or soap, woolen mills, tanneries and chemical works, as well as in many other lines of industry.

Agriculture still remains the world's most important industry, as nearly 36 per cent. of our people are engaged in it, and all the rest depend upon it. Mr. James J. Hill has said that

> In the last analysis, commerce, manufactures, our home market, every form of activity runs back to the bounty of the earth by which every worker, skilled or unskilled, must be fed and by which his wages are ultimately paid.

And Liebig, in the preface to his great work on "Chemistry in Its Applications to Agriculture and Physiology" calls attention to the fact that

> a rational system of agriculture can not be formed without the application of scientific principles, for such a system must be based on an exact acquaintance with the means of nutrition of vegetables, and with the influence of soils and actions of manure upon them. This knowledge we must seek from chemistry, which teaches the mode of investigating the composition and of studying the character of the different substances from which plants derive their nourishment.

In this great domain, the services of chemistry include the fixation of atmospheric nitrogen, the elucidation of some of the ways in which atmospheric nitrogen enters into organic combination and of the methods whereby organic nitrogen is prepared for plant food, the analysis of soils and the determination of their relation to plant growth, the analysis of plants and agricultural products and a study of the influence of environment upon their composition, the manufacture of fertilizers and their adaptation to the needs of different soils and crops, the protection of the farmer from fraud when he purchases the same, methods of utilizing plant food and of conserving it for future use, the establishing of the general principles of plant growth and the chemical changes involved, the replacing of natural dyes and drugs by synthetic articles, the manufacture of artificial silk and the saving of the natural silk industry from threatened obliteration, the production of other artificial fibers and fabrics, the mercerization of cotton, the manufacture of substances to take the place of resins and shellac, the rescue of crops from impending destruction by providing effective insecticides and fungicides, the production of valuable substances from former wastes (cottonseed oil, corn oil, gluten from starch factories, cream of tartar from wine lees, and the like), and of industrial alcohol from crop refuse. Dr. H. W. Wiley has expressed the opinion that

> The application of the principles of chemical technology to the elaboration of raw agricultural products has added a new value to the fruits of the farm, opened up new avenues of prosperity, and developed new staple crops.

The introduction and enactment of our Pure Food and Drug laws, as every one is aware, were due primarily to the tireless activity of this same chemist.

It probably has not occurred to the layman that the chemist might appear also in the rôle of a land reclaimer, and yet the discovery of commercially profitable methods of manufacturing alizarin and indigo from coal tar has set free for other crops hundreds of thousands of acres formerly devoted to the raising of madder and indigo.

In the realm of animal industry, the chemist has elucidated the laws of animal nutrition and taught the farmer how to adapt his feeding-stuffs to the needs of his stock, so as to secure the maximum return in work, meat, fat or milk, and by analytical control again protects him from fraud when he buys his cattle feed. When diseases attack the herd, chemistry supplies antiseptics and powerful remedies of all kinds. Not so many years back, it was the custom to build slaughter houses on the banks of streams into which all the refuse was turned. But chemistry has revolutionized all this, and the old joke about the Chicago packing-houses using every part of the pig, including the squeal, is now not far from the truth. In modern abattoirs and packing-houses, the hides are used for leather; the grease is converted into soap, candles, oleo and glycerol (for nitroglycerin manufacture); the blood and scrap into blood albumen, fertilizers and potassium cyanide (for gold extraction, among other uses); the horns and hoofs into jelly, buttons, knife handles, etc.; the feet, bones and heads, into glue, bone oil and bone-black. The skim-milk formerly wasted, now surrenders its casein, from which so many interesting and useful articles are manufactured. Chemistry has also provided a number of satisfactory leather substitutes, while the waste from real leather is converted into fertilizer or glue.

It is chemistry again which has put into the hands of the builder non-combustible building materials, such as iron and steel, cement, brick, plaster, terra-cotta, tiles of all kinds, porcelain, pottery, stoneware and earthenware, and all kinds of metallic furnishings and fittings; fireproofing solutions for the safeguarding of combustible materials; paints and varnishes, to protect from weathering and decay; preservatives to prolong the life of the timber and ward it from the attacks of marine borers, molds and fungi.

Formerly all the alkali required for soap manufacture was derived from wood ashes; but the chemist has shown how it can be secured much more economically by the electrolysis of common salt.

In addition to all this, and much more which could be cited, it is chemistry that provides a majority of our most potent anesthetics, antiseptics and remedies of various kinds. In his fight with disease and death, the physician has no more powerful or resourceful ally than the chemist. Finally, the processes of the living organism, plant or animal, are primarily chemical, and instead of the formation of organic compounds in the living organism being longer referred to a mysterious "vis vitalis," the question has lately been raised seriously as to whether life itself is not merely one of the products, or the resultant, of a definite series of chemical reactions. Dr. Schaefer, in his presidential address before the Dundee meeting of the British Association for the Advancement of Science, after calling attention to the comparatively few elements and simple compounds of which living matter is composed, said "The combination of these elements into a colloidal compound represents the chemical basis of life; and when the chemist succeeds in building up this compound, it will without doubt be found to exhibit the phenomena which we are in the habit of associating with the term 'life'"; and he fur-

ther suggests "that heredity also is one of the questions the eventual solution of which we must look to the chemist to provide."

I like the old familiar concept of the human organism, not as an individual but as a community, a humming, bustling hive of industry, where each separate cell has its own special kind of work to perform; some splitting up the raw material as it is received into simpler substances and classifying these for transmission to other cells, where they are built up into materials necessary for the life and development of the organism; some cells carrying on a process of benevolent assimilation, others "doing an illicit still business"; with the great central pumping station driving life and energy to the remotest corners of the establishment. That is not only the most fascinating organic chemical laboratory in the world, and its most important chemical industry; but it is also the one which concerns us most intimately. Whether we live or die within the next five minutes, depends absolutely upon whether the reactions now going on in all the minute organic laboratories of our bodies continue in their normal healthy course or suddenly go wrong.

Chemistry has been well characterized as "the intelligence department of industry." It does not skim the cream of other men's labor, but is itself so great a creator of national wealth that the actual money value of its services is beyond computation.

In this brief and very superficial fashion, I have endeavored to give you some idea as to what chemistry means to our present-day civilization. All of these remarkable achievements are but the outcome of patient and painstaking research in the field of pure chemistry. Investigations in pure science laid those broad and deep foundations upon which applied science has erected the wonderful structure of modern industrial operations. Small wonder, then, that the establishment of a chair of research in pure chemistry is a cause for gratification and encouragement.

No one can tell at what instant some observation recorded in the course of a research may suddenly become of immense importance. When Cavendish, 130 years ago, read a paper before the Royal Society describing the formation of nitric acid by the passing of an electric spark through air, it certainly never occurred to any one present that the question of the fixation of atmospheric nitrogen might one day prove the means of saving the human race from starvation, and yet such may turn out to be the case in the years to come. Perkin had no intimation that the experiments conducted during the Easter vacation of 1856, in the effort to obtain quinine synthetically, would result in a billion dollar world industry in coal tar dyestuffs; nor could Bessemer have foreseen that his process would one day save the world over two billion dollars annually.

The nineteenth century has been described as the Age of Physics and Engineering, since it witnessed such triumphs as the development of steam and gas engines, and the utilization of electricity as a source of light, heat and power, and as a means of communication. The twentieth century will quite certainly be an Age of Chemistry. Germany realized this some years ago, with results that are now evident to all.

If we would not be left far behind in the race, we must pursue a similar course, and that at once. We have yet to convince many of the nations of the earth that the form of government in which we believe, and to establish which our ancestors died, is the best not only for the freedom and happiness of the individual, and the development of the noblest intellectual and moral standards, but also for the growth of the country in physical strength and resource-

fulness, and that in the hour of need it will not be found wanting in the vital matter of industrial efficiency and solidarity which is the corner-stone of all military power.

In the terrible world war now raging, the law of the survival of the fittest will be found as inescapable, immutable and inexorable in the case of nations as it is with individuals. It listens to no explanations, accepts no excuses, and knows absolutely no pity. Our own country is beginning to awaken to the fact that civilization unarmed by science is at a terrible disadvantage in the event of a struggle for existence, and that this arming can not be done at short notice. The result is a loud and urgent call upon the universities, colleges and technical schools of the land for help.

Conspicuous among those answering this call most effectively are the University of Pittsburgh and its Mellon Institute. Conducting an energetic campaign for the education of the community to a better appreciation of science, pointing out to the manufacturers wherein the chemist can aid them, and winning their support for chemical research, prosecuting skilful investigations directed to the immediate public needs, and turning out highly-trained scientists, this university has already made an enviable record of service, and has placed under a lasting debt of gratitude not only the city of Pittsburgh, the chemical profession and the nation, but the entire world of humanity as well; for its activities minister in the highest degree to the progress of civilization, and its achievements ultimately become the property of all mankind.

Robinson has defined education as "the process of fitting the individual to take his place and do his part in the life of his age and nation," and no educational institution at the present time can discharge this responsibility faithfully unless it accords, in its equipment and in its curricula, adequate recognition to so comprehensive a science as chemistry which, in its wide sweep, touches almost every phase of human life and endeavor.

Two years ago, in an address which I had occasion to deliver in England, I ventured the opinion that the most pressing need of the day was the proper endowment of chemical research, by the founding of great research institutes and the creation of research professorships. That opinion I have not altered.

The establishment in this university of the Willard Gibbs Professorship of Research in Pure Chemistry is an occasion for warmest congratulations: to the chancellor and trustees of the university on the momentous step they have taken in the direction of building up a great new school of graduate and research work in pure chemistry; to the distinguished director of the Mellon Institute, Dr. Raymond F. Bacon, for his wise foresight in securing such a department as a powerful means of advancing progress in industrial research; to the university and its Mellon Institute, on securing as the first incumbent of the new chair a most talented teacher and investigator, Dr. Martin A. Rosanoff, whose researches have already won for him an international reputation; and to Professor Rosanoff himself, on being selected for this high honor.

That this new chair should bear the illustrious name of Josiah Willard Gibbs is peculiarly appropriate, for, as an investigator in the field of pure chemistry, Ostwald has called him "by far the greatest scientist America has yet produced," and Le Chatelier has said that his work marks an epoch as important as that of Lavoisier. Abstruse and recondite as those researches were, their fundamental bearing upon the development of our science is daily becoming clearer.

In felicitating the chancellor and trustees, it is not necessary to point out that a university's greatness is not determined by the magnificence of its plant, its athletic prowess, or the size of its student body, but by the number and importance of its graduate schools; and that the standing of a graduate school, in the judgment of those whose opinion is really worth having, is measured by the amount and quality of its output of genuinely original investigation. The extent of the assistance which a university secures from its surrounding community in the creation of such splendid graduate schools as we see here, is not infrequently the reflection of the attitude of the university authorities themselves toward such work; and the city of Pittsburgh is indeed fortunate to have at the head of its famous university a chancellor and trustees who know how to prize original scientific investigation at its real worth, and under whose fostering care and guidance it is certain to have full opportunity for development.

To the staff of noted teachers and investigators already connected with this university, Dr. Rosanoff has been called, and I bring to him the congratulations of our chemical department at Columbia and our best wishes for a long, happy and useful career.

He is an unusually gifted man—chemist, physicist, mathematician, linguist—and intends to devote his versatile talents to the difficult, but very important field of physico-organic chemistry. He should be a very happy man to-night, for I know that it has been his ambition to be permitted to devote his life to research in pure chemistry, and happiness has been defined as the quotient obtained by dividing our ambition by our achievements. There is no doubt that he will do all in his power to widen the boundaries of knowledge in his chosen field, and that he will succeed, through his own labors and those of his junior colleagues, research associates and students, in bringing honor and prestige to the chair.

I would gladly explain to you the importance of the numerous discoveries he has already made, but time does not permit, and much of it, I fear, would be about as fascinating to the uninitiated as an attempt to expound the fine points of Sanskrit syntax.

Accordingly, I will limit myself to a few of his more notable contributions.

Fractional distillation is an ancient process, but it has remained largely an empirical one. True, its practical applications have developed and experience has shown the particular value of various forms of distilling apparatus, but the underlying theory has continued more or less in dispute and it has been impossible to calculate accurately in advance the correct arrangement of the distilling heads necessary to realize a maximum separation of the components of a liquid mixture; the only way to find out having been to assemble an outfit and make a trial run. Professor Rosanoff's studies of the problem have convinced him that the conclusion arrived at by previous investigators to the effect that a single regulated still-head sufficed to separate completely binary mixtures was not in accord with the facts. By an application of the theory of partial vapor pressures he has corrected this error and shown that not one, but a series of still-heads is necessary, the temperature of each of which bears a definite mathematical relation to that of every other one. This has been experimentally confirmed very many times during the past three or four years, and it would appear that research in pure chemistry has at last placed this age-old process upon a firm scientific basis. The American Chemical Society recognized the fine quality of

the work by awarding Professor Rosanoff its Nichols Medal for the year 1910. As distillation plays a very prominent part in many of our leading industries, the importance of the investigation requires no comment.

Other valuable researches conducted by Professor Rosanoff had to do with such well-known generalizations as the theory of electrolytic dissociation and the law of mass action. In the case of the hydrolysis of sucrose, and the decomposition of tertiary amyl esters, other investigators have reported results which were at variance with one or both of these hypotheses, and the consequence has been increasing confusion and perplexity. By long-continued study of these problems, on the part of his collaborers and himself, Dr. Rosanoff has proved both mathematically and experimentally that the observations primarily responsible for this troublesome condition of affairs were inaccurate and misleading, and that the theories of electrolytic dissociation and of mass action are beautifully confirmed in these particular cases also. To bring order out of chaos is indeed a welcome service. The "hydrolysis of sucrose" probably sounds highly technical to the layman, but it is a chemical reaction upon which depends the evaluation of the entire sugar output of the world. As our country has something like three hundred million dollars invested in the sugar business, the problem obviously has its practical side as well.

All of his work has been characterized by the refinement and precision of the physico-chemical measurements made, the painstaking and laborious efforts to eliminate all possible sources of error, and the immense number of experiments carried out before any conclusions are drawn.

In the coming years, I can wish for him no higher reward than that he may succeed in communicating to his students some of his own contagious and enthusiastic love of the subject, since this is the greatest been in the gift of any teacher and the one which brings most happiness to the donor. With that compelling inspiration, the student will get the dry facts of the science in due time; without it, knowledge alone can never make him a really great man.

For his comfort, I would remind my colleagues of the words of Epictetus:

> Remember that such was, and is, and will be the nature of the universe, and that it is not possible that the things which came into being can come into being otherwise than they do now; and that not only men have participated in this change and transmutation, and all other living things which are on the earth, but also the things which are divine. And indeed the very four elements are changed and transmuted up and down, and earth becomes water and water becomes air, and the air again is transmuted into other things, and the same manner of transmutation takes place from above to below. If a man attempts to turn his mind toward these thoughts, and to persuade himself to accept with willingness that which is necessary, he will pass through life with complete moderation and harmony.

I am confident that he will never become so deeply engrossed in his researches as to lose sight of the main purpose of all education, which is to make better men and more useful citizens; and that his efforts will always be directed to training men to be not only great scientists, but also great Americans, and that in so doing he will not fail to impress upon each student that the individual is but one of the players in the mighty drama of human life and endeavor, and that he should therefore play his part worthily, as owing a debt both to his profession and to the community in which he lives. "What art do you teach, Protagoras?" asked Socrates. "I teach the art of citizenship," replied the sophist. "Then, indeed," said Socrates, "you teach the noblest and best of all arts, for it includes all others." And Epictetus writes:

You will do the greatest service to the state, if you shall raise not the roofs of the houses, but the souls of the citizens; for it is better that great souls should dwell in small houses than for mean slaves to lurk in great houses.

After all, it is the development of genius that is most important for the progress of the world. The lives of such men as Faraday, Liebig, Pasteur, Williard Gibbs, are of inestimable value to mankind. Though these men themselves have lived their little day and passed on, their work is immortal; and it is certain that many of the investigations carried out in the laboratories of this splendidly equipped university will still shine with undimmed luster long after these noble buildings have crumbled in decay.

The pyramids that cleave heaven's jewelled portal;
Elean-Jove's star-spangled dome; the tomb
Where rich Mausolus sleeps—are not immortal,
Nor shall escape inevitable doom.
Devouring fire and rains will mar their splendor;
The weight of years will drag the marble down;
Genius alone a name can deathless render,
And round the forehead wreathe the unfading crown.

Marston Taylor Bogert
Columbia University

THE TEACHING OF THE HISTORY OF SCIENCE

ITS PRESENT STATUS IN OUR UNIVERSITIES, COLLEGES AND TECHNICAL SCHOOLS

The significance and merit of the present investigation, while of great interest to the author, remains for those actively engaged in the work of teaching to determine. It is only recently that any great indication of a change in method in science teaching in our higher institutions has been manifested. They have found that "science," as a means of education, assumes a broader aspect in courses upon the history of scientific progress—such as those originated by Harvard University and the Massachusetts Institute of Technology. Proof of the coming change can be seen in the character and number of critical reports and articles appearing in the various scientific and educational journals. For those who seek further enlightenment, a short bibliography will be found appended.

This paper is divided into two parts, namely, the arguments regarding the intrinsic value of the history of science as a study and as a factor in educational efficiency. These arguments are supported by citations from erudite men, active in the promotion of scientific training. The second division contains facts, tables and other material necessary to show the present condition and trend of the subject, and if possible to validate the arguments upon the value of a course in history of science as a whole, over courses in the more specific fields—as the history of chemistry, or astronomy, etc.

I

The discussion centering about a course which should give some idea of the history of science as a whole is of comparatively recent date, at least in this country. It arose in the demand of a small body of progressive scientific men for a study that would give our students (scientific and technical) something more than mere facts, theory and technic, in solving problems. We have heard too much of the orthodoxy of science, its over-specialization, and (as one of our foremost philosophers has put it) a certain amount of crudeness and pettiness in our methods and opinions concerning problems in science—at least in comparison with European scholars.

During the last decade of our scientific progress there has come about a development and reaction from the extreme and powerful method of specialization, both in methods of research and in teaching, whereby stress is laid upon the cultural and broadening effects in scientific study—the learning of principles and not mere facts. One factor in this development, though not seemingly important in the past, is now demanding its full recognition, the *teaching* of science from the *historical* point of view, not entirely from the economic or problem-solving reasons—the historical development of the principles, the evolution of science itself, showing correlation and interrelation between the most simple and the most

complex concepts. This then may be assumed to be the purpose and intent of the study of the history of science, or as Dr. H. C. Brown, of the philosophy department (Stanford University), states it, it shows a growing recognition of the value of mind. Intelligence was a plaything for the ancients, a consolation for the medievals, but an instrument for the modern.

In the words of Dr. C. R. Mann, of the University of Chicago:[1]

> One immediate consequence of this sort of historical study would be the much-desired humanizing of science, for we should be compelled to recognize the various ways in which science has cooperated with the other phases of human activities in bringing us into our present condition.

The theory of Dr. Wilhelm Ostwald[2] is that "the history of the sciences offers the best and most authoritative material for the study of law in the evolution of mankind." Further, as Professor Ostwald sees it, the history of science is not merely history for its own sake, but a new method of study, a new way of getting at the results of research.

From John Fiske in his study of evolution as a method of study,[3] we find these precepts:

> Study the present in the light of the past. The easy work of science is mostly done. Those who would continue work must study, not living objects, but laws that govern them. Whether planets or mountains or molluscs or subjunctive modes, or tribal confederacies, be the things studied, the scholars who have studied them most fruitfully were those who have studied them as phases of development. Their work has directed the currents of thought.

Ostwald[4] emphasizes the importance of historical study as an interpreter of the interrelationship of science and life:

> The nineteenth century was too full of creative work in the various fields of science to give historical studies their full play. The new century, on the other hand, though it has achieved already some very remarkable results in the way of positive additions to our knowledge of the forces of nature, will offer a larger field for historical studies, for the reason that the practical value of such studies will be more clearly demonstrated. The author deprecates the idea that pure science can have no connection with life. The great investigators, he says, "were almost without exception in their younger days passionately enthusiastic over some concrete, practical aim, and it was in the course of the further and higher development of these problems (which indeed followed rapidly upon one another) that they themselves attained a wider and higher point of view. The tree of knowledge raises its crown high in the ether of pure science, but it is rooted in the firm ground of human needs and activities.

Pres. Henry S. Pritchett,[5] after discoursing upon the progress of science in past ages, and especially upon the larger aspect of science from the middle of the nineteenth century to the beginning of the twentieth, brings out the fundamental contrasts which stand out most prominently:

> First, the last fifty years have seen a greater betterment of the theoretical basis of physical science. Second, this development has been marked by a notable stimulation of scientific research, a differentiation of scientific effort, and the creation thereby of a great number of special sciences or departments of science. Third, the possession of a secured theoretical basis and the intellectual quickening which has followed it have resulted in the application of science to the arts and to the industries in such measure as the world has never before known. These applications have to do with the comfort, health, pleasure and happiness of the human race, and affect vitally all the conditions of modern life. Fourth, perhaps in many respects the most significant of all, is the effect which has been produced upon the religious faith and the philosophy of life of the civilized world by the widespread introduction of what may be called the modern scientific spirit.

Lastly, here we may add perhaps the most fundamental principle, which should also be vital indeed in the purpose of the study of the

[1] "The History of Science, an Interpretation," *Pop. Sci. Mo.*, April, 1906, Vol. 76.

[2] See introduction to his book, "Die Entwicklung der Electrochemie."

[3] Quoted from excerpts in Dr. D. S. Jordan's "Syllabus on Evolution," 1895, pp. 4–5.

[4] Quoted from a review of his book, "Die Entwicklung der Electrochemie" (Leipzig, J. A. Barth), in *The Nation*, Vol. 90, p. 637, June 23, 1910.

[5] *Atlantic Monthly*, November, 1907, p. 614.

history of science—namely the development of the scientific concepts or ideas (see Ostwald's "Naturphilosophie") and the methods evolving such.

Up to the present time the range and domain of science includes all that is of nature, and from her the four great interrelating principles have been evolved. Manifestly, they are well known, but for contemporary testimony they will be restated. Dr. W J McGee[6] has termed them "the four cardinal principles of science—namely, the indestructibility of matter, the persistence of motion, the development of species, and the uniformity of nature." The philosophy of each of these accepted doctrines is the history of science.

It is interesting at this point to note the following ideas from a powerful article by Dr. J. F. Woodhull:[7]

> Culture courses, or information courses, are often spoken of scornfully as a smattering of all the 'ologies.
>
> Science culture differs in its methods from the old classical culture, but it has the same spirit and same object.
>
> The weakest thing about our research to-day is that our men are not widely informed.
>
> Davy, Faraday, Tyndall, Pasteur, Humboldt, Huxley, Maxwell, Agassiz, Cooke, Shaler, Newcomb, all preached the doctrine that science is good for culture and should be given to all.
>
> Value scientific courses—not simply because they cultivate the perception and reasoning faculties, but because they fill the mind with lofty ideals, elevated conceptions and noble thoughts; indeed there is no better school in which to train the esthetic faculties of the mind—taste and imagination—than the study of natural science.
>
> The history of science tells of a multitude who have worked in faith for the love of knowledge, and made themselves and their fellows more noble men.

The history of science is referred to here as including all the divisions of pure science, not emphasizing one over another, nor one apart from another (as, for instance, physical and biological). No matter what particular specialty he chooses, the whole field of science is to the student of science vital and important. In this manner its history will comprehend what relations exist between the development of the various subjects in various periods, the correlation of these divisions and their advances, the problems of science, and lastly, the evolution of the sciences, all will be to him an intellectual pleasure and a noteworthy part of his training and education.

[6] Washington Academy of Science *Proceedings*, Vol. II., pp. 1–12, 1900.

[7] "Science for Culture," *School Review*, Vol. 15, p. 123, February, 1907.

II

The problem this paper is attempting to consider is twofold: First, to show somewhat the historical development of these courses in the history of science; second, to argue that although a course in the history of a specific subject may be desirable, it does not possess the value and merit in education that a strong and well-developed general history of science has. It will be also shown that such a course is the most economical in regard to time, service to the university authorities, and service to the student. Various single courses can be combined and correlated, to make one course (general) for 3 or 4 hours throughout the year.

In America the early history of the development of the science instruction in our higher schools is one certainly important, and possessing interesting characteristics; and the history of the courses upon the history of science—general and specific—has had almost a parallel treatment.

The early development of this movement can be traced from the crude materialism of the older physicists in Europe, to about 1880. In the following few years the period of overspecialization was coming to a climax, and with this, an undercurrent of idealistic and critical tendencies in scientific thoughts was being manifested. Probably the first conscious indication of interest in the history of science dates back to 1883, when "Die Mechanik in ihrer Entwickelung, historisch-kritisch dargestellt," by Dr. Ernst Mach, first made its appearance, followed by Karl Pearson's "The Grammar of Science" (1892) and in Germany by Dr. Wilhelm Ostwald's "Naturphilosophie." In France Henri Poincaré's work

has its influence and bearing, and in Italy Anton Favaro.

Out of this critical-idealistic tendency to react from the materialism of science grew the idealistic-historical movement. This is sometimes thought of as the synthetical and generalizing phase in scientific learning. The effect of that movement in this country was slight at best, but a beginning had been made in Harvard University by Dr. Richard in 1890, and in the Massachusetts Institute of Technology by Dr. Sedgwick and Dr. Cross, somewhat earlier. Dr. Richard's course was a series of voluntary lectures upon chemical philosophy, but it was virtually a course upon the history of chemistry. Later, receiving official recognition, it changed to its present title—historical development of chemical theory and elementary physical chemistry. From this grew out (1911) the present courses in the history of the physical and biological sciences given by Dr. L. J. Henderson.

The development of the courses by Dr. Sedgwick had somewhat similar progress. In 1887 he offered a course of twelve popular evening lectures upon the history of biology; later this was transferred to the regular institute curriculum, and became known as the history of the natural sciences. Also in the same year Professor Cross gave to the seniors a reading course on the history of the physical sciences, requiring French and German as well as elementary physics and laboratory work as prerequisites. It was not until 1905 that these courses were combined and given as a regular course called history of science—offered by Professors Sedgwick and Tyler.

In 1879–80 at Johns Hopkins University a course of twelve lectures upon the history of chemistry was given, but in such a manner that it has never been considered a regular and definite course.

An interesting fact, again manifested here, is that most of our pioneering in intellectual activities inevitably has its origin in the older New England institutions. To Harvard University belongs the credit of first establishing a definite and systematic course in the history of a special field in science, and to Massachusetts Institute of Technology, the recognition of the more general field in the historical work in science. That the authorities of Harvard have fully recognized the value and purpose of this new advancement in science teaching, is revealed, not alone by the establishment of the history of science as an independent "group" in their curriculum, but in doing something of a missionary character, as well. This is a very notable instance in educational progress. Dr. L. J. Henderson was, during the past semester, the exchange professor to five middle-Western colleges—Beloit, Carleton, Colorado, Grinnell and Knox. At each of these institutions he gave a course of twelve lectures upon the history of science. The order and sequence in which they were established and given are excellent, and therefore a copy of the lecture-series is here added:

1. What is Science?
2. Ancient Astronomy and Its Importance.
3. Ancient Physics.
4. Ancient and Modern Science.
5. Harvey and the Renaissance of Biology.
6. Galileo to Newton, and the Renaissance of Mechanics.
7. The Seventeenth Century.
8. The Eighteenth Century.
9–10. The Great Synthesis of the Nineteenth Century.
11. The Industrial Revolution and the Scientific Revolution.
12. The Value of Science.

Having now shown in brief what the beginnings of this movement were, it will be of further interest to trace it through the few other schools to the present. We are still to bear in mind that the specific courses *only* are being considered; the general history of science courses are of late origin, and exist only in a few schools. The response to this new phase of science instruction was slow, in many cases irregular, and in some cases indifferently considered. This fluctuation is only apparent in the older schools in the early period—as, for instance, when the history of astronomy was once given, it is now discontinued, and *vice versa*. In 1892–93 Yale University first offered a course in the history of mathematics

and in astronomy; both were discontinued, and to-day there is established a course in the history of biology. The University of Chicago likewise in the same year announced courses in the history of astronomy and of chemistry, but several years later these were discontinued.

The effort to keep up this work at the University of Chicago has never ceased, however; we find the history of physics and of geology offered, as well as a course in the history of geography (which of course is not a pure science subject). At the same university the scientific faculty attempt to institute a very unique and ambitious plan for the fostering and development of the historical courses in science. A letter from Dr. F. R. Moulton explains it:

> The department of philosophy was to initiate the system by giving an introductory course in Ancient Science, developing it to about Galileo's time. From here the following departments (mathematics, physics, chemistry, astronomy, biology and geology) were to carry over the modern period of science in their particular fields.

These courses were to be correlated, and so given as to form a large and orderly sequence in the history of science. The one difficulty in the scheme, Dr. Moulton writes, is that it was impossible to get the same students to continue throughout the year; and worse still, the methods of the different professors were so diverse that there was really no continuity in the discussion. The plan has now been abandoned. But for a substitute there has been developed an excellent series of courses by Dr. G. H. Mead in the philosophy department, on a closely allied subject—the history of the ancient and modern scientific concepts.

In time a number of other schools followed —Universities of Pennsylvania, Cornell, Illinois, Michigan, Northwestern, Stanford and California. This response was felt to be necessary in the west as well as in the east, and California and Stanford have maintained it consistently. From 1895 to date a course in the history of chemistry has been offered at the University of California, with slight and varying degree of success. In the department of astronomy from 1896 to date, the historical course has been found to be in greater demand, whereas the history of mathematics was given only for a period of three years. Stanford University has, from the time of its foundation (1891), offered a course in the history of chemistry almost continuously, except that of late it has been given in alternate years. The course in the history of physics has been abandoned. Instead, however, a "Journal" course is given with the same idea, *i. e.*, discussing certain epoch-making problems in physics, from the historical point of view.

A further study of the individual colleges and universities will reveal a like condition regarding the changeable character of historical studies in the science departments, and the reasons for this are many, apparent to the individual schools themselves; namely, lack of students, lack of interest, improper correlation and requirements, and no ideals of what constitutes true breadth of culture and efficiency in scientific training. A very noticeable and astonishing neglect exists in a number of our larger schools, in which one naturally would expect greater efficiency and continuity. They omit entirely the historical treatment of some of their strongest scientific departments. A historical course should certainly be given in the departments where some degree of strength and prominence has been attained. California and Michigan in astronomy, Harvard in chemistry, Chicago in physics and mathematics, have carried this idea out partly.

A study of the conditions in smaller schools is naturally not very different from the larger, except in the total number of courses offered, as well as the types, which center around the physical sciences.

In order to obtain a scientific account of the present trend of the historical courses given, a statistical study was first undertaken, which was divided into three parts by grouping the universities, colleges and technical schools.[8] There are about 600 higher institutions of learning in the country, and it was found impractical and unwise to use the entire number for this particular study. It is also untrust-

[8] Selected from the Report of U. S. Commissioner of Education, 1913, Vol. II., pp. 193–209.

worthy, for comparative study, to segregate universities from colleges. Therefore some means of standardizing was resorted to, in order to eliminate schools having no concern in the discussion, such as theological seminaries, trade schools and preparatory schools. The problem was very much simplified by rating the efficiency and high educational qualities of a school, not by numbers in registration, but by the quality and type of instruction, the work given, and by library facilities and accessions. The first element was easily determined by using the accepted list of schools, as passed by the Association of American Universities for the Prussian Kulturministerium.[9] These schools will be known as the association group. The second group is the library standard group, containing colleges whose library accessions are over 10,000 volumes. The reason for making this limit was that equipment and not large student body was to determine the strength of the school. A school of from 300 to 500 students and library of 5,000 volumes did not compare with a school of from 200 to 400 students and 10,000 volumes. The third division will be called the technical group, composed of about 50 of the technical, agricultural and mechanical arts colleges.

At best, these three groups are arbitrary divisions, but they will serve the purpose of this study.

Of this list of over 600 schools, more than 500 catalogues and college curricula were examined thoroughly, and the information desired was found in some 350 catalogues, of schools conforming with the above restrictions. In all cases the information was taken from the latest catalogues—either 1914–15 or 1915–16—except in a few instances. The facts searched for are as follows:

(*a*) Type of historical courses—general, physics, chemistry, etc.

(*b*) Hours of lectures, whether given in one semester or both; or alternate years.

(*c*) Graduate study and requirements for "majors" in departments.

[9] See *Educational Review*, December, 1913, p. 510–518.

(*d*) Other facts bearing upon this discussion.

The arrangement of the statistics gathered together in this paper is for the purpose of showing what each institution is doing. One can, for example, see at a glance what work is offered at Chicago or Harvard, and compare it with courses in other institutions. While this study is as scientific as it was possible for the writer to secure reliable data, it must be taken with some consideration of the probable errors existing. It was found in at least four to six cases, through special correspondence, that a number of courses were offered in the catalogues, but not actually given for various reasons. Another interesting fact regarding these figures, which on first assumption might indicate a definite policy of the colleges concerned, and one which parallels with the attempts of the University of Chicago plan, is that there appears to be a continuity in some of these courses, which in reality does not exist. For example, a college may offer a series of three or four history courses in the specific sciences; these are not correlated, and they are not completed by courses of the same type in the remaining sciences. The schools having this apparent arrangement of continuity of courses (see Table III.) are Alleghany, Carleton, Columbia, Iowa State, Mt. Holyoke, California, Illinois, Michigan, Pennsylvania and Pittsburgh. The criticisms of such a continuity are well sustained by Professor F. R. Moulton. However, a small college may succeed in this where it is better adapted to alternate its courses. If this could be accomplished, no doubt there are educational factors of merit in such a system, that are not to be had in a single general history course—namely, a more comprehensive treatment of the special subject, and a study of the development of its theories and technic.

Table I. is an analysis of the data gathered from the principal or association group. The subject-matter is arranged for a comparative study of courses, hours of lectures, and class enrollment. Column one contains the list of nine subjects comprising pure science, technically speaking; column two, the total num-

ber of courses in each subject in this particular group; in three and four are the number of half and full courses offered (column two is the sum of both); column five contains the total number of hours devoted to lecturing or instruction, and in six and seven are the average number of hours per course and average number of students per course.

TABLE I

Group Ia (Association Standard)—113 Schools

Subjects	Total No. Courses	½ Semester Courses	Full Yr. Courses	Total No. Hrs. of Instruction.	Average No. Hrs. per Course per Wk.	Average No. Students per Course
Math.....	47	27	20	113	2.4	14
Physics ..	19	10	9	31	1.6	7
Chem....	38	17	21	74	1.9	13
Astron. ..	13	11	2	33	2.5	9
Geology..	4	4	—	12	3.0	3
Biology ..	14[10]	6	8	28	2.0	8
Botany ..	4	2	2	12	3.0	2
Zoology..	17[10]	17	—	36	2.1	—
Psychol. .	6	6	—	16	2.6	—
	162[11]	100	62	355	2.3	8.0
General history of science	14[12]	9	5	30	3.0	51.0

In the total number of courses offered in the 113 schools, two subjects stand out more prominently than all others—mathematics and chemistry. The explanation of this condition is to be found by a study of the catalogues of courses themselves and of the answers to questionnaires sent out. The subjects reveal two differing points of view, though both are, apparently, desired by students.

In the case of mathematics, the large number of courses offered is due to the fact that the teaching methods (especially those for the elementary teacher) are taught in combination with the history of the subject. The largest class enrollment in the history of mathematics is found to be at Teachers' College, Columbia University; it is given by Dr. David Eugene Smith. The average for four years (1910–14) was 54 students. In consideration of the average large class attendance (14—the range being 2 to 54) it is to be inferred that the course is primarily adapted for teachers or those preparing to teach.

In the case of chemistry the conditions differ decidedly. The total number of courses is 38, and from the general expression of opinion regarding its place in the curriculum, the history of chemistry is given solely for its intrinsic value. This value is expressed in educational terms as culture, breadth of chemical learning; it is also given with a great deal of philosophic interest by the instructors concerned. And in only one case is it offered and not given. Here again the class enrollment is high, 13 being the average attendance, and the range, from 1 to 85. This largest class in the history of chemistry for the five years, 1910–15, was composed of 85 students under Dr. Theodore W. Richards, at Harvard. The value and interest of such a course tend also to increase, judging from the answers received to the questionnaire, the larger class attendance, and the fact that a number of half-year and alternate-year courses are breaking down to a regular full-year course. These give credit for two hours each semester, which seems to be the average time for a lecture course.

There are probably only two reasons to be advanced for this state of affairs in chemistry. In the history of chemistry, beside its broad philosophic interest, the subject itself involves more of the fundamentals of other sciences, and consequently approaches the realm of the more general history of science, thereby appealing to the interest of the scientific students. Before passing, it might be well to mention a one-hour course given in the University of Pennsylvania on the history of chemistry in America, by Provost Smith. This course was instituted in 1908; it is primarily for graduates. A course in the general history of chemistry is also given; it had its beginning in 1896.

Taking up our next largest subject from the point of view of numbers, we find physics offered in 19 schools in this group. Here the study reveals a decided and strong reversal of

[10] Courses in *Evolution* included.

[11] Almost 15 per cent. of these are given in alternate years.

[12] Five of this number are Harvard Exchange lectures.

conditions from those found in the preceding two subjects; in fact, the remaining subjects—astronomy, geology and the biological sciences, though not so large in numbers of schools represented, and class attendance—do not show indifference to the teaching, value and purpose of the course—that is, in the majority of cases. In the teaching of the history of physics this condition is marked; and for such a subject, known to be one of the fundamental sciences, this attitude is not to be expected; the study should approach chemistry in its higher educational value.

As it is, 19 courses are offered in this group of 113 schools; of these, six courses have been dropped, or are to be discontinued, and in addition, in two cases they are represented in the catalogue, but not given. The average class attendance is small (7; the range being 1–12), being half of the first two subjects mentioned.

The next study of special interest is astronomy. Here we have a subject involving other features not included in the first three fundamental sciences. In considering the small total number of schools offering astronomy (15) we must bear in mind that this is a highly technical and specialized subject, requiring expensive instrumental equipment, and that it is therefore not to be found in many curricula. If at all, it is usually represented only by a single course—a general descriptive course, and going beyond the observatory visits only in the larger schools.

This number (15) is reduced to 13, for in two schools it was discovered that instead of a history of astronomy, the history of nautical astronomy and the history of geodesy were given. The average class was found to be 9 students, with a range from 2 to 43. The relation this large class attendance of 43 (five years' average) has to the prominence of the department (University of California astronomical department, with Lick Observatory) is probably well explained by the cases already cited (mathematics in Columbia and chemistry in Harvard). As to the strength of the cultural value astronomy and its history has, all scholars agree.

Combining the study of botany and zoology with biology, we have here again a very interesting situation. The actual number of history courses in these subjects is small in comparison with the other courses, but in the number of students they are fair. Over 75 per cent. of these courses are represented by a course in evolution, history and theory. The reason for this inclusion is probably one personal to the writer; but, from his experience, it is a just reason. At two different times he has taken a course upon the theory of evolution from the biological and philosophical departments, and in each case the historical method was strongly emphasized. Probably in all the history of thought no greater principle has been discovered and developed than the doctrine and theory of evolution. One can not study evolution unless the principal factors of biology are considered, and these have a historical antecedence or sequence; and *vice versa,* one can not study biology unless he constantly bears in mind the evolutionary principles involved.

In the matter of the interest and theories of those teaching, there is a firm desire to advance this subject. From the small percentage of returned answers the figures do not represent actual conditions, but as a whole no doubt, they are fairly good. At Northwestern University a course is being given which, according to the title[13] and other information regarding methods of conducting the course, bears evidence of decided value. The class (1913–14) had a total of 13 students, with a good percentage of graduates. According to another letter, from Whitman College (Walla Walla, Wash.), Professor H. S. Brode offers a series of well-selected and comprehensive lectures on the history of biology, in conjunction with the general course—the attendance in class being on the average, 30. The reason for mentioning these special courses is to show recognition of their value, and the spirit of interest found alike in different types of schools—large and small. In Yale University in the department of zoology, we find again a valuable

[13] "Source of Biological Ideas, from the Revival of Learning to the Present," by Dr. W. A. Locy.

course on the history of biology given by Dr. L. L. Woodruff as a graduate course. From 1908 to 1915 it has been offered five times, with an average of 6 graduate students, out of a department list of approximately 12 graduate students. Advanced students in biology from the college are admitted by the consent of the instructor. Bryn Mawr College offers an interesting course entitled historical biology. It is partly lecture and laboratory work, including a critical analysis of the theory of evolution.

The courses in evolution by itself, its history, theory and relation to other fields of thought through the historical development, will not be discussed here. Their importance to this field of the history of thought has a larger bearing than is at first inferred, and therefore these courses were included in this study as possessing merit.

The study of the history of botany is offered in four schools—University of Chicago (a 5-hours' quarterly course). Johns Hopkins University (3 hours), Mt. Holyoke (3), and Smith College (2). In the University of Chicago, the course is given as a seminar by Dr. John Coulter. He sounds the keynote of all historical courses, in desiring to give the students a historical background in their field of study. Johns Hopkins has a course of a type distinct from others in that it takes up special topics and discusses their historical sequence. At Smith College Dr. W. F. Ganong has offered a course for five years, which was not actually given because not enough students elected it. However, he is convinced that the historical basis of science is very desirable, and in view of such, he writes that one of his teachers was assigned to study the history of botany as a specialty, and at the same time was to collect the botanical classics.

Concerning the remaining two topics—geology and psychology—nothing of any great value was found, except in the case of geology. Two courses were offered and not given—not from lack of teaching interest, but from lack of students. University of Chicago's plan is a seminar. At Princeton University, though no formal lectures are offered, the graduate student is required to read before graduation a selected number of books, of which two are historical.[14] In the University of Michigan, the course is a small seminar for advanced students, given only once (to 3 students), but offered again this coming year—1915–16. Professor W. H. Hobbs writes, however, in a very optimistic tone; he says that the subject is susceptible of presentation to large classes along broad lines, with great profit.

Some geologists believe that the historical phase of their subject is better taken up as outside, independent reading—that teaching of the technic is of greater value (as regards the instructor's time) than lecturing upon history. The author is inclined to differ from this opinion. The average student would rather listen to lectures and spend the spare outside time upon the non-essentials of life.

In this investigation, psychology was included too late to send out questionnaires and make such further study as was necessary. The history of psychology is comparatively a new study; in fact, the subject itself has only recently been established as a science. Heretofore its destiny has been controlled by the philosophy department, and to a great extent it is even yet. But the importance of the subject is gradually attaining the dignity of an independent science, in the same degree as mathematics, physics, etc. Therefore, although the research in the records of this subject is not as wide as in some of the others, a brief survey of a few courses will be given.

Six schools of group I., and one school of group II., offer this subject with its historical significance—Harvard, Chicago, Clark, Mt. Holyoke, Illinois and Michigan. The course offered at Harvard is practically an advanced one, and open only to students who have taken four other courses in the department. It lays special emphasis on those portions of the history which are of great importance to the understanding of psychology's concepts and problems. Chicago apparently places great stress upon this subject; in the annual catalogue for 1913–14 are listed three separate

[14] Geikie, "Founders of Geology," Merrill, "History of American Geology."

courses—the "History of British Psychology," the "History of German Psychology," and "American and French Psychologists" (for graduate students). Michigan has a course entitled the "History of Modern Psychology," primarily for graduates.

In summing up the results of this study in the specific historical courses (as given in group I. *a*, Table I.) and comparing them with the study of the general historical courses, and also with the study of the other two groups (I. *b* and I. *c*) the figures themselves seem to be arguments that establish the validity and the greater merits of the general history of science course for all groups of schools. This statement is made, notwithstanding the fact that the percentage of successfully conducted courses in the specific group is probably large.

We have in the total number of courses offered in group I. *a*, 162 courses (not including seven unrelated courses previously noted). Of this number, 100 are half-year courses, and 62 full-year courses, with a total of 355 hours of instruction, thus giving an average of 2.3 hours per course, with 8.0 students as average class enrollment. Also we find, of the 162 courses and 113 schools, an average of 1.4 courses per school.

Considering now, briefly, what the figures are concerning the history of science in general, we have some telling facts. The comparison may not seem to be exactly fair, because the more general subjects are only found in the larger institutions (not including the Harvard Exchange lectures), as against the large number of smaller schools offering special courses. However, for a general study of the trend of the movement, we must look to the larger schools, and therefore this comparison may answer our purpose. In this group there are 14 general history courses, and from these 5 constitute the Harvard Exchange lectureship, which, according to the terms of exchange, is only temporary; the subject-matter changes with professor and department. The course at Throop College of Technology (a third group school) was discontinued or crowded out. Reed College presents a different type of historical course, which is not to be considered a complete course, the historical treatment being combined with a general science course. Lehigh University has a course which is a combination of the biographies and the progress of science—1 hour, 1 semester. Pennsylvania's course is given by the philosophy department, and is known as "The Philosophy of Nature." Chicago and Columbia both offer courses for the quarterly and half-year terms, in the history of the physical sciences; at Chicago Dr. Mann attempts to consider something of the history of science in America. The remaining four larger schools —Harvard, Princeton, Carnegie Institute of Technology and Massachusetts Institute of Technology offer complete courses in the history of the physical and biological sciences. In the last few years the Carnegie Institute of Technology has manifested a great activity in the general aspect of this study. Last year a course on the philosophy of science was offered, and a new, more general course upon the history of science is being planned.

The number of the smaller schools interested is encouraging, and indicates progress: Hamline University, Hunter College, Simmons College, Massachusetts Agricultural College and University of Cincinnati.

TABLE II

	General Courses (Groups I *a*, I *b*, I *c*)	Specific Courses (Group I *a*)
Total numbers of courses	20	162
Total numbers of hours	42	355
Av. numbers of hours per course.	2.2	2.3
Av. nos. of students per course.	39	8.0
Av. nos. of courses per school.	1.0	1.4

On further analysis of the subjects, represented in group I. *a, b, c,* it can be shown (by dividing these courses into physical and biological groups—exclusive of mathematics) that the average number of hours for instruction throughout the year of each, is 2.2 hours and 2.4 hours. The average number of students for the physical group is larger than the biological group. Comparing the figures of the two divisions given in Table II., we find the

relative proportion is about the same as far as the number of hours per course is concerned; but the attendance per class in the general history of science figures is decidedly in the advance. The "specific" class enrollment of 8 students shows that the course is limited, that it is for those *prepared* to take it; whereas the "general" class enrollment is 39 students. This is, of course, the average of 8 schools; it was not possible to get figures for the balance, and therefore it would be unfair to assume that this was the average for 20 schools. It is probable, however, that this average could not alter very greatly were the entire list of figures to be had. It shows, too, that the value of the subject appeals to a large number of students, providing the question arises, "Does the size of the class indicate the general approval of such a course?"

Taking also the average hours per course from the first 8—or the largest schools—we have 3 hours, which is approximately the proper number of hours for a course of this type. Of course, all of these courses represented are not full history of science courses, as later discussion will show; but they approach the type of course advocated, namely the Harvard plan. And as far as it is possible to show by this study, the Harvard type fulfils the ideal requirements, both in treatment, number of hours for lectures, size of class, and requirements. With an advanced course in the nature of a seminar, the study would be practically complete, for those who wished to follow the subject further.

Having mentioned the subject of continuity of courses, the following table, containing schools, courses and hours of lectures, is given for further discussion.

In Table III. are listed those schools having three or more subjects bearing upon a number of particular historical courses in science. The reason for selecting these is that it takes at least that number to constitute a well-balanced continuous course in the history of the physical sciences—those three to be, preferably, mathematics, physics and chemistry. The grouping given in the table is composed of all possible arrangements of subject-matter, including the biological sciences.

TABLE III

(Group Studies, Good Substitutes for a General Course: Mathematics, Physics, Biology—Zoology and Botany—Included.)

Schools	No. of Courses	Subjects	Total Hrs.	Av. Hrs. per Course.
Allegheny....	4	Astr. Phys. Chem. Biol.	6	1.5
Bryn Mawr...	3	Math. Phys. Biol.	5	1.6
Columbia.....	3	Math. Astr. Chem.	7	2.3
Indiana.....	4	Math. Phys. Biol. Bot.	13	3.1
Iowa State ...	3	Math. Phys. Chem.	6	2.0
Mt. Holyoke .	5	Math. Astr. Phys. Chem. Bot.	11	2.2
Univ. of Calif.	4	Math. Astr. Phys. Chem.	9	2.2
Illinois.....	3	Math. Phys. Chem.	5	1.6
Michigan.....	4	Math. Astr. Chem. Geology (4)	10	2.5
Pennsylvania .	4	Math. Astr. Phys. Chem.	8	2.0
Pittsburgh....	3	Math. Chem. Astr.	7	2.3
Wisconsin....	3	Math. Chem. Zool.	5	1.6
		Average.....	...	2.7

Assuming that continuity and system were established in these courses, we should have no further argument as to their worth. But as a matter of fact, as far as it was possible to ascertain, no such condition existed in any case.

The class attendance in every case was not obtained, so that this phase of the problem is omitted. However, from the point of view of hours of instruction, the average was found to be little more than two hours (2.7). In all cases we are referring to the regular periods of instruction, namely, weekly recitations, etc. It is evident that the figure given does not satisfy the average requirement for standard (3 hours a week, general course) and can not in this sense be substituted as equal.

Probably better results would have been obtained had the investigation gone further into the question regarding the percentage of students in the scientific department of each school who took the historical course, and those who did not take the course. It was planned to work this problem along such lines,

but it was found that too many questions in the circular letter would be discouraging to those asked to fill them out, especially at a time shortly before the commencement period.

Having considered the study only in one group of schools, let us for a moment give a brief summary of the subject and its status in other groups (I. *b* and I. *c*) and compare with the first (I. *a*). Though no great results are to be expected in this comparison, sufficient interest is there to warrant setting off this table into three parts.

In regard to the total number of specific courses, we have this proportion: 27 per cent. of the courses are in the history of mathematics; 22 per cent. in the history of chemistry; approximately 9 per cent. in the history of physics; 5 per cent. in that of astronomy; 2 per cent. in history of geology; 7 per cent. in history of biology; 6 per cent. in history of zoology, and 2 per cent. in history of botany; 20 per cent. in the history of science, philosophy of science and psychology.

Restated, we have the figures: 65 per cent.

TABLE IV

Schools	No. Schools	Gen. Hist.	Math.	Phys.	Chem.	Astr.	Geol.	Biol.	Bot.	Zool.	Psych.	Phil. of S.	Total No. Courses	Miscel. Hist. Courses
Group I. *a*—Association	113	14	47	19	38	13	4	14	4	17	6	27	202	Hist. of geodesy Hist. of naut. astr. 3 courses hist. of forestry.
Group I. *b*—Library.....	189	3	42	11	26	4	3	9	2	5	1	6	112	2 courses hist. of geogr.
Group I. *c*—Technical.....	50	3	3	2	10	0	0	1	0	1	0	1	22	Hist. of engineering Hist. of mech. engineering Hist. of heat engineering.
Total.....	352	20	92	32	74	17	7	24	6	23	7	34	336	

From the best source,[15] the number of universities, colleges and technical schools in the United States is 598; of this number we have listed 352. The balance (246) came within the restrictions placed upon them. Of the 352 schools having courses in almost all of the sciences, 224 schools offer courses treating of the history of science (both general and specific subjects); 128 schools do not. In other words, approximately 63 per cent. of the schools listed have 336 courses—or, 37 per cent. of all the schools (598) have 336 courses. However, the basis of our calculation will be the schools given in Table IV.—352 schools and 336 courses.

Group I., 113 schools, has 60 per cent. of the courses.

Group II., 189 schools, has 33 per cent. of the courses.

Group III., 50 schools, has 7 per cent. of the courses.

[15] U. S. Commission Report, 1913.

of the courses in the physical sciences, and 15 per cent. in the biological group (including the history of evolution). The question is, then, is there more emphasis placed upon the physical group than on the biological? One is impressed, after studying Table III. and the notes following, and Table IV., with the idea that there seems to be a tendency in that direction.

This study can not properly close without at least indicating the general methods of presenting these courses in the classroom. There is no one method predominating, but in general the two prevailing methods show a natural and progressive tendency in academic instruction.

Whenever a text-book is published upon a special history of physics, mathematics, etc., it was noted that its topics are presented by the text-book with the aid of lectures and papers. When the subject is for advanced students, the seminar, reports, and references to

classical memoirs, etc., are resorted to. With few exceptions, all of the combined continuous courses just discussed are being carried out in this way.

At Harvard, Dr. Richard's method in "Historical Development of Chemistry" has decided merit, for its unique treatment. To quote from him:

> The course is conducted by a series of lectures, in which the main topics are written upon the board, somewhat after the manner of a syllabus. The students are forced to do some reading by a system of extempore theses, according to a plan outlined in a paper entitled "A Partial Substitute for Examination"—see *Educational Review*, November, 1908.

Attention was called in a former paper[16] to the bibliographical material in the field of the history of science. It was chiefly foreign publications, of a periodical nature. Here, attention should be directed to a special bibliography which every man, in science especially, should have in his library—namely, the "John Crerar Library List of Books in the History of Science," by A. G. S. Josephson, cataloguer (Chicago, 1911). To this a supplement is being prepared, and as a companion volume there is soon to appear a "List of Books on the History of Industry and Industrial Art." Such a volume upon the desk of any scholar in science, after he has perused its contents, can not fail to reveal to him the vast importance of his own and allied subjects—not merely as a specialist, but as a student of human affairs.

CONCLUSION

Notwithstanding the present status of the greater number of courses upon the history of science in a special field (as was shown in Table IV.), it remains to note the tendencies of progress. In so doing, this paper will conclude with a brief summary of a few replies received from men prominent in science, philosophy and education, upon the question of the intrinsic value and the future of the history course in science.

From the facts as they have been deduced in the discussion of Table I. and Table IV., there is strong evidence of the probability that the specific courses are losing favor (with the exception of chemistry and mathematics, for reasons already given, and of isolated cases in the other subjects) and that the general course is coming to be the accepted standard for history in science. The slight significance of the history of the several sciences is probably the best argument for the more general history course.

Therefore, as the figures now stand, it would seem that it is far more advantageous to offer a course of three hours throughout the year with a larger class enrollment in the general subject, than to have so many scattering courses offered with an average of two hours, and a very small class attendance. From the point of view of efficiency in educational administration, and educational values, both in the instructors' and students' interest, the general course is far more desirable.

The salient points of the value and importance of a course, such as its use for culture, general depth, breadth of scientific knowledge, and training, were all brought out on the introduction of this paper. And as far as further study of the subject is concerned, a list of short articles will be found appended as a bibliography of the subject.

It is evident from the inherent nature of the specific history course in science (such as physics, chemistry, etc.) that it has value only for a limited number of students. Whereas the course of the more general history of science, treated broadly and thoroughly, has a far greater application and merit—and affects a larger number of students. The methods of treatment in both cases vary only in the degree of application, and not essentially in subject-matter, except in the amount considered vital to a well-developed course. For example, take the history of chemistry. In such a course the instructor can with proper allowance (for the confines of all specific courses are restricted more or less) dwell upon the history of chemical theories in a far larger sense than it is possible or practical to do in the more general history of science course. He can also en-

[16] See Science, N. S., Vol. XLI., pp. 358–360 (1915).

large upon the technic of its methods, give a more minute examination to the development of chemical concepts (historically), and finally, move with greater intimacy in the study of the lives of eminent chemists.

On the other hand, in the study of the history of science as a whole, we come to the chronological order, and principles, as well as the relationship and parallel progress of all sciences, their order of logical sequence, and application of science to the progress of civilization, and a conception of what the world owes to science. Also it allows a wider selection and interest in the vital part of all historical study—the biographical study. Lastly, in seeking for a greater analysis of the problems of the future in science, the history of science furnishes the background for all future investigations and progress.

The question is not, do we need more courses in our over-developed curricula, but a larger degree of intensive and correlated courses in order to bring out the better human faculties for greater service and deeper insight into the problems of nature. The failure of universities, colleges or technical schools, to make the necessary provisions for courses in either specific or general history of science, decreases their general efficiency, especially in their scientific curricula. From the point of view of economy in academic administration, and taking into consideration the merits of each case, as they have been set forth, the choice should certainly be with a general history of science course.

As Professor A. O. Lovejoy, of Johns Hopkins, writes:

> One hesitates to suggest further increase in the already too-diversified supply of mental pabulum urged upon undergraduates; but I should think an introductory course in the history of science would be a valuable addition to the curriculum of any college.

Further, he says that the history of science is assuredly important enough to be recognized as a distinct branch of teaching and of research. Professor Josiah Royce writes also; he points out how

> a deadening influence of a too exclusive absorption in the technique of one's own specialty could be prevented by the study of the history of science. Such a study is at once humanizing and an important auxiliary training towards acquiring a good method in technical work.

It is interesting to note that a number of years back some of our prominent men in science pointed out the present trend of this study as it is brought out in this investigation. Dr. R. F. Moulton, of the University of Chicago, was of the opinion that "it is worthy of a much better place than it now (1909) has"; Dr. Henry Crew, of Northwestern University, expressed a hope that as time went on the history of science should become a separate topic of study for advanced students; Dr. Florian Cajori, of the University of Colorado, inclined to the opinion that the stronger universities of the country would pay more and more attention to the history of science as the years went on.

Having now seen what the "expert opinion" has been regarding the future interest in the history of science, especially in our more prominent universities, within the last five or six years, it may be confidently expected that in the next few years very rapid progress will be made. No doubt many conditions have prevailed which retarded this progress, and probably the strongest one is that no well-adapted text- or source-book, or selected reading, is available. This is evident, and scientific men are aware of this deficiency. At the present time, two series of volumes are being prepared to aid the methods of teaching this subject. At the Massachusetts Institute of Technology, Professor W. T. Sedgwick and Professor H. W. Tyler are preparing a two-volume text entitled "Outlines of the History of Science," designed expressly for the use of their own classes. Volume I. is to deal with the rise and progress of science and scientific spirit to the fall of the Roman empire. Volume II. treats of the development of science in medieval and modern times.

Dr. Walter Libby, of the Carnegie Institute of Technology, with the collaboration of Dr. Locy and Dr. Crew, of Northwestern University, is preparing a series of short volumes: the History of the Biological Sciences, the History

of the Physical Sciences, an Introduction to the History of Science, and a probable fourth volume on the Applications of Science.

It has often been emphasized that the history of science can not be taught because of its encyclopedic extent. This objection can be overruled. It is true that we can not all be a Leibnitz, or possess minds of the type of his; however, in our modern methods of training or in specialized education, we may at least obtain the broadest viewpoint possible—through historical methods and their perspective, and withal, historical inspiration.[17] The principles of history have a criterion based upon scientific methods, just like any other subject of study intended for philosophical interpretation. This must be recognized by the future historian of science.

And when the historian of science is fully imbued with the "Geist und Leitmotiv of human learning," then, and only then, can the history of science be of value, and be possessed of a future. The final message of the history of science is to show the high plane of science—that which has given life, stability, truth and wealth—in its universal activities and its established international character as the arbiter of the future of man and of peace.

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[17] See "Outlines of the Principles of History," by Johann G. Droysen (1897), trans. by E. B. Andrews, pp. 9–58.

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THE COMMITTEE ON POLICY OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

The committee met at 5 P.M., on November 15, in the room of the New York Academy of Sciences, American Museum of Natural History, New York City (continued later at the Hotel Majestic), with Messrs. Pickering, Paton, Woodward, Noyes, Fairchild, Cattell and Howard present.

The preliminary announcement and arrangements for the Columbus meeting were considered. It was recommended that public addresses be worded so as not to allude to the present war in a way which might give offense. Dr. W. W. Campbell, president of the association, was appointed as delegate and Dr. L. O. Howard, permanent secretary, as alternate to the Second Pan-American Scientific Congress. The question of the relation of the association to the congress was referred to a special committee consisting of Messrs. Woodward, Howard and Humphreys.

Mr. Pickering submitted a report of progress for the committee on expert testimony.

Mr. Woodward submitted a report on the Coburn bequest.

Other matters considered by the committee and its recommendations will be submitted to the council at the Columbus meeting of the association.

At 9.30 P.M. the committee adjourned.

L. O. Howard,
Secretary

SCIENTIFIC NOTES AND NEWS

As was stated in Science last week, the Nobel prize in chemistry for 1914 has been awarded to Professor Theodore William Richards, of Harvard University, and the prize in physics to Professor Max von Laue, of Frankfort-on-Main, for his work on the diffraction of rays in crystals. The prize in medicine has been awarded to Dr. Robert Barany, of

the University of Vienna, for his work on the physiology and pathology of the vestibule of the ear. According to a Reuter dispatch from Stockholm, two of the Nobel prizes for 1915 will be awarded as follows: chemistry—Dr. Richard Willstaetter, of the University of Berlin. Physics—divided between Professor William Henry Bragg, of the University of Leeds, and his son, W. L. Bragg, of Cambridge University, England, for research in the structure of crystals by use of the Röntgen rays. The prize for medicine for 1915 is reserved until next year.

NOVEMBER 24 was the seventy-fifth birthday anniversary of John Alfred Brashear, whose name has been intimately associated, for half a century, with the civic, scientific and intellectual progress of Pittsburgh. His friends celebrated his many years of unselfish and enthusiastic devotion to the public welfare, by a popular subscription dinner, at which an opportunity was afforded to express to him their appreciation of his services, and their hopes for long continuance of his useful and inspiring life. The dinner was held in the banquet hall of the Soldiers' Memorial Hall and was in charge of a committee of seventy-five.

Nature states that the committee which was constituted last year to promote testimonials to Professors Perry and Harrison on their retirement from the staff of the Imperial College (Royal College of Science) has now completed its labors. The testimonial to Professor Harrison, who has been associated with the department of mathematics and mechanics during thirty-two years, has taken the form of an illuminated address, accompanied by valuable personal gifts. In the case of Professor Perry, former students of the Finsbury Technical College desired to be associated with the testimonial, in recognition of his valuable services to that institution prior to his joining the staff of the Royal College of Science in 1896. The governing body of the Imperial College having readily consented to act as trustees, the aim of the committee was to establish a permanent memorial of Professor Perry's work in the form of a medal or prize to be awarded annually at each of the two institutions. Dies have been prepared from designs by Mr. Charles Wheeler, of the Royal College of Art. A silver medal will be awarded annually to a student of the Imperial College for distinction in mathematics and mechanics, and at the Finsbury College a similar award will be made for distinction in mathematics and engineering.

WITH addresses by Governor Frank B. Willis, Dr. Thomas C. Mendenhall, Chief C. F. Marvin, of the Weather Bureau, and Professor J. Warren Smith, the Ohio Academy of Science will hold its quarter-centennial meeting on November 26 and 27. Professor Smith, who is president of the academy, will give the annual address. Dr. Marvin's subject will be "The Work of the Weather Bureau." Dr. Mendenhall will discuss "The Relation of the Academy to the State and to the People of the State." Professor William R. Lazenby, of the department of forestry of the Ohio State University, will give a historical sketch of the academy.

DR. WALTER O. SNELLING, of Pittsburgh, has bought land in Long Island City on which he will erect laboratories for chemical research.

ALFRED W. BOSWORTH, associate chemist at the New York Agricultural Experiment Station, who has been engaged in experiment station work during the past sixteen years, has accepted the position of chief of the department of biological chemistry of the Boston Floating Hospital, beginning about the first of the new year.

HERBERT T. OSBORN, a graduate of the Ohio State University in 1909, son of Professor H. Osborn, of the department of zoology, has been sent by the Sugar Planters' Association of Honolulu to Formosa, to secure parasites to use in Hawaii to exterminate the cane beetle.

AT the Chemists' Club, New York, on November 10, there was a gathering of the following industrial chemists, at a dinner tendered by the management of the exposition, to discuss plans for the next National Exposition

of Chemical Industries: Raymond F. Bacon, Chas. H. Herty, Henry B. Faber, A. D. Little, E. F. Roeber, George D. Rosengarten, T. B. Wagner, L. H. Baekeland, M. C. Whitaker, B. C. Hesse, Adriaan Nagelvoort and Chas. F. Roth; also Mr. R. D. Hollman and Mr. F. W. Payne of the International Exposition Company were present, all of whom will serve on the advisory committee for the 1916 National Exposition of Chemical Industries to be held at the Grand Central Palace, New York City, during the week of September 25, 1916. Dr. Chas. H. Herty was elected to serve as chairman of the committee for the coming year. Plans for enlarging and increasing the scope of the exposition were laid, which will assure a very large exposition both from the attendance standpoint as well as exhibits. The plans include using several floors of the Grand Central Palace, with speakers in the evening and motion pictures during the day from 11 A.M. to 7 P.M.

The anniversary meeting of the New York Academy of Medicine, held on November 18, was devoted to the subject "Disease and Crime—an Analogy." The speakers were George W. Wickersham, president of the Bar Association of New York, "The Concern of Society in the Problem of Crime"; Thomas Mott Osborne, warden of Sing Sing prison, "The Part which Penal Institutions Might be Made to Play in the Solution of the Problem," and Judge Harry Olson, chief justice of the Municipal Court of Chicago, "The Progress that has been Made and What the Future Promises."

Dr. Henry Charlton Bastian, the distinguished London neurologist, the author also of books on the origin of life, died on November 17, at the age of eighty years.

Raphael Meldola, professor of organic chemistry in the University of London, died on November 16, at the age of sixty-six years.

Dr. Philippe Hatt, the French astronomer and hydrographic engineer, has died at the age of seventy-five years.

Dr. F. Hasenöhrl, professor of physics at Vienna, has been killed in the war. He succeeded Boltzmann, whose pupil he was and whose works he edited, in the chair at Vienna.

The twenty-fourth meeting of the American Psychological Association will be held at the University of Chicago, on December 28, 29 and 30. The annual dinner-smoker, with the address of the president, Professor John B. Watson, will occur at the Quadrangle Club on the evening of December 29.

The fifteenth annual meeting of the American Philosophical Association will be held at Philadelphia, Pa., on December 28, 29 and 30, in acceptance of the invitation of the philosophical department of the University of Pennsylvania. The session will begin on Tuesday afternoon. The meeting will have some special features, which will be announced when arrangements are completed. The association meets alone this year, and there will be no joint discussion, and no special topic as at recent meetings.

According to the *Weekly Bulletin* of the New York City Department of Health in a service of less than two years as commissioner of health of the city of New York, Dr. S. S. Goldwater effected the following reforms:

1. Placing most of the important supervisory positions on a full-time basis, with a corresponding increase in the salaries attaching to the positions.

2. Establishing a bureau of public health education under a director chosen as the result of an open competitive examination, and insisting on education as an indispensable factor in public health administration.

3. Establishing a division of industrial hygiene, thereby properly claiming as a health department function an important but hitherto neglected field of public health activity.

4. Establishing a division of statistical research by readjustment of existing positions within the bureau of records.

5. Revision of the sanitary code and formulation of a complete set of regulations thereunder.

6. Advancing the work of school medical inspection by providing that private physicians may make the required physical examinations.

7. Broadening the application of the dog muzzling ordinance and thereby reducing the prevalence of dog bites and the number of rabid animals in this city.

8. Waging a persistent campaign against fraudulent patent medicines and securing the adoption of an ordinance providing that the names of the ingredients be printed on the label of all nostrums sold in this city.

9. Providing for the regular annual physical examination of all employees of the department of health.

10. Reorganizing the bureau of food and drugs and placing at its head a recognized authority in this field, chosen as the result of an open competitive examination.

11. Inaugurating a campaign of education against the use of alcohol as a beverage.

12. Insisting on the recognition, as a menace to health, of overcrowding in the street cars, and compelling the street railway companies to provide the service needed to the limit of their capacity.

THE program for the year of the Society of the Sigma Xi, of Northwestern University, is as follows:

October 28. "Chemical Control of Body Functions": Professor R. G. Hoskins.

November 17. "Scientific Problems of Flight and the best Possible Ways of Attacking Them": Director John F. Hayford.

December 9. "Galileo": Professor Henry Crew.

January 12. "Bill's School and Mine": Professor W. S. Franklin. Initiation of new members.

February 17. "Five Outstanding Events of Biological Progress": Professor W. A. Locy.

March 9. "Conduction of Pain and Temperature": Professor S. W. Ransom.

April 13. "Microbic Warfare in the Intestinal Tract": Professor A. I. Kendall. Dinner and annual meeting; election of new members.

May 18. Last meeting of year, to be addressed by a speaker from another university. Initiation of new members.

UNDER the auspices of the Rush Society and other medical organizations of Philadelphia lectures on medical and allied subjects have been arranged as follows:

The Samuel D. Gross Lecture of the Pathological Society of Philadelphia, October 14, by Dr. Eugene L. Fiske: "The Increasing Mortality from Diseases of the Heart, Blood Vessels and Kidneys."

The Twelfth Rush Society Lecture, November 29, Professor Daniel J. McCarthy, University of Pennsylvania Medical School: "Medical and Social Problems Incident to War."

The Mütter Lecture, December 17, Professor Rudolf Matas, Tulane College of Medicine: "The Fundamental Principles that Underlie the Surgical Treatment of Aneurysm."

The Thirteenth Rush Society Lecture, January 21, Dr. F. M. Allen, Rockefeller Institute of Medical Research: "Investigative and Scientific Phases of the Diabetic Question with Their Probable Relations to Practical Problems of Clinical Medicine."

The Frederick A. Packard Lecture of the Philadelphia Pediatric Society, February 8, Professor Charles M. Campbell, Johns Hopkins Medical School: "The Neurotic Child; Some Familiar Symptoms and Their Problems."

The Fourteenth Rush Society Lecture, March 7, Professor Richard P. Strong, Harvard Medical School: "An Investigation of Typhus Fever in Serbia." (This lecture is also the annual address before the Alpha Omega Alpha Honorary Medical Society.)

The Fifteenth Rush Society Lecture, April 6, Professor John M. T. Finney, Johns Hopkins University: "What Constitutes a Surgeon." (This lecture is also the annual address before the Undergraduate Medical Society of the University of Pennsylvania.)

Annual Address of the Pathological Society of Philadelphia, April 27, Professor William H. Park, University and Bellevue Hospital Medical College. (Title to be announced later.)

UNIVERSITY AND EDUCATIONAL NEWS

APPROXIMATELY $1,000,000 is to go to Yale University under the will of Justus S. Hotchkiss, of New Haven. The trust fund thus established is to be shared equally among the academic, law and theological departments.

THE plans for the merger of the Medico-Chirurgical College and the Medical School of the University of Pennsylvania were agreed upon finally on November 15, following a conference of representatives of the two institutions. The Polyclinic Hospital of Philadelphia, which maintains a post-graduate medical course for physicians, may also merge with the University of Pennsylvania.

IN Washington University (St. Louis), as announced in SCIENCE last week, Dr. Leo

Loeb has been appointed to a newly established chair of comparative pathology in the medical school. The creation of this special research department is made possible by a fund provided for five years by friends of the university for the purpose. The university announces also the appointment of Philip A. Shaffer, Ph.D., as dean, June 3, 1915, and the following promotions: Borden S. Veeder, M.D., to associate professor of pediatrics; Robert A. Gesell, M.D., to associate in physiology; Philip C. Jeans, M.D., to instructor in pediatrics.

Mr. W. F. Turner, of Beltsville, Md., has been appointed to the position of extension instructor in animal husbandry at the Massachusetts Agricultural College, the position left vacant by the resignation of Mr. G. E. Story, who recently went to the University of Vermont as professor of animal husbandry.

Dr. Robert Retzer, formerly of the University of Chicago, has accepted the professorship of anatomy and deanship of the Creighton Medical College, Omaha. Mr. A. J. Key, formerly assistant in anatomy at the Johns Hopkins Medical School, has been made instructor of anatomy. Dr. G. W. Earle, of Tufts College, has been appointed instructor in pathology and director of the clinical laboratory.

Dr. Leonard Rowntree, associate professor of medicine in the Johns Hopkins Medical School, has accepted the position of professor and chief of the department of medicine in the University of Minnesota.

The changes in the faculty of the engineering departments of Brown University for the year 1915–16 are as follows: Professor P. B. Perkins, who was assistant professor of mechanics last year, has been appointed assistant professor of applied physics and teaches some of the courses in physics and electrical engineering. Mr. James A. Hall, who was on leave of absence last year and spent the year in the engineering department of the Link Belt Company, Philadelphia, has returned to take up the position of assistant professor of mechanical engineering, having charge of the courses in machine design. Mr. Frank C. Blake has been promoted from assistant in mechanical engineering to instructor. Mr. Thomas C. Shedd, who was instructor in mechanical engineering last year, has withdrawn from the university to accept a position with the Phœnix Bridge Company. Mr. Robert F. Field, who was instructor in electrical engineering for a period of five years, has resigned to take up graduate work in physics at Harvard University.

DISCUSSION AND CORRESPONDENCE

ARTIFICIAL DAYLIGHT

To the Editor of Science: In the issue of Science for October 15, 1915, Professor Simon H. Gage discusses a color filter, recently devised by Dr. H. P. Gage which produces an artificial daylight when used with the nitrogen-filled tungsten lamp. Under the caption "Artificial Daylight for the Microscope" Professor Gage not only commends highly the use of artificial daylight in microscopy but also refers to its great potential value in the textile and dye industries, in chemistry and in medicine. Inasmuch as Professor Gage apparently is not cognizant of the fact that artificial daylight was scientifically achieved several years before the work of Dr. H. P. Gage, that attention was called several years ago to its possible use in microscopy, and for the past several years various daylight units have been on the market, that at present several thousand daylight units of the types developed by the writer are in daily use, it seemed advisable to give the readers of Science a brief résumé of the subject.

In 1900 Dufton and Gardner[1] described a colored glass for accomplishing the desired result and since that time many have worked on the problem. In 1911 Ives and Luckiesh[2] described a color filter which produced a sufficiently accurate artificial daylight and described the entire procedure. Quite a number of these units were installed in various fields

[1] British Assn. Report, p. 631, 1900; *Jour. Soc. Chem. Ind.*, Vol. 23, p. 598, 1904.

[2] *Elec. World*, May 4, 1911; *London Illum. Engr.*, Vol. 4, p. 394, 1911.

but, owing to the fact that a dyed gelatine was necessary to obtain a final correction, this unit was limited in application. Since that time both Ives and Brady, and the writer independently produced such filters in a single glass.[3] Mr. R. B. Hussey[4] developed a filter in 1912 for use with the intensified arc. Mees, Pirani, Weertz, and others have also worked on the problem.

The units developed by the writer have been designed for solving various problems and include accurate color-matching units for the most exacting color-work as well as more efficient yet sufficiently accurate units for the rougher color-work. Several thousand of these units consisting of a single colored glass are in daily use and have not only passed the spectrophotometric tests, but the tests of many different practical applications. The writer[5] emphasized the application of these units in microscopy and besides being applied to this field, many units are in daily use in color-matching, lithography, cigar sorting, medical diagnosis, horticulture, oil refining, surgery, color photography, hair dressing, art exhibits, painting, paint factories, chemical laboratories, laundries, in millinery, dry goods, clothing and jewelry stores, textile mills, art schools, paper mills, and many other places.

M. LUCKIESH

NELA RESEARCH LABORATORY,
NATIONAL LAMP WORKS OF G. E. CO.,
NELA PARK, CLEVELAND, OHIO

INJECTIONS OF THE BUNDLE OF HIS

TO THE EDITOR OF SCIENCE: In a letter published in SCIENCE of November 12, 1915, Dr. A. W. Meyer, of Stanford University, complains that injustice has been done to his former associate, Dr. Lhamon, who devised a method of injecting the bundle of His, by the publication of a note by Dr. Cohn describing hearts injected by this method, before the appearance of Dr. Lhamon's paper.

The circumstances were as follows: Dr. Meyer showed me the injections when I was in his laboratory in California and, on my return, as the preparations had interested me very much, I spoke of them to a number of men including Dr. Cohn. I made it clear at that time that the method had been devised by one of Dr. Meyer's assistants and every one who heard of it was aware of this. Dr. Cohn was not then my assistant, but was working at the Rockefeller Hospital, where he experimented with the method in connection with his own work.

Dr. Meyer's letter is so worded that it might give the impression that I, after an apparently friendly visit, betrayed his confidence by having an assistant anticipate his publication of the new method. This is unfortunate, for I can not believe that he intended to imply such a thing.

The publication was not made by one of my assistants, nor at my suggestion, nor even with my previous knowledge of its nature. Furthermore I was not present at the meeting of the New York Pathological Society when the injected hearts were demonstrated, else I should have emphasized the fact in the discussion that this was a method devised in Dr. Meyer's laboratory. Nevertheless it appears in the published discussion that the method had first been heard of through me.

I am impelled to write this in defense of Dr. Cohn, because I feel convinced that he had no intention of claiming priority. Every one connected with the matter regrets exceedingly the inopportune publication of the first note and the carelessness which let it pass into print without definite mention of Dr. Lhamon's work.

W. G. MACCALLUM

COLLEGE OF PHYSICIANS AND SURGEONS,
COLUMBIA UNIVERSITY,
November 18, 1915

TO THE EDITOR OF SCIENCE: In SCIENCE of November 12, 1915, appears a letter from Professor A. W. Meyer, of Stanford University, in which, in behalf of his former associate, Dr. Lhamon, he very vigorously asserts a claim for priority in injection of the conduction system in mammalian hearts. If the sole purpose of

[3] *Trans. I. E. S.*, Vol. 9, p. 840, p. 937, 1914; *Elec. World*, Sept. 17, 1914; *Jour. of Franklin Inst.*, Vol. 177, p. 471, 1914; *Elec. World*, Apr. 4, 1914.

[4] *Trans. I. E. S.*, Vol. 7, p. 13, 1912.

[5] *Elec. World*, July 10, 1915.

this letter were to clear up any misunderstanding as to priority on behalf of Dr. Lhamon, no reply would be required, but since the letter is so written as to suggest that an attempt has been made by my associate, Dr. Alfred Cohn, to unjustly obtain credit for this discovery, it seems that a reply is demanded, especially since Dr. Meyer has apparently drawn conclusions concerning Dr. Cohn's motives which are quite out of harmony with what his friends know of his character.

I am quite familiar with the work that Dr. Cohn has done on this subject, and have now carefully reviewed the publications in question, and also have seen the correspondence which has passed between Dr. Cohn and Dr. Meyer. In the light of all that I can learn in regard to the matter, it would seem that so far as the actual matter of priority is concerned Dr. Meyer is needlessly alarmed, and it is very unlikely that in future generations any one is going to claim that Dr. Cohn was the first to prepare such injections. Dr. Cohn himself, in a letter to Dr. Meyer which Dr. Meyer quotes, has stated that "so far as priority is concerned, not only I, but every one acquainted with the subject, gives and has given full credit to Lhamon."

The chief purpose of Dr. Meyer's letter, therefore, seems to be to take Dr. Cohn to task for having presented before the New York Pathological Society in December, 1911, ox hearts showing injection of the conducting system. These hearts were prepared by Dr. Cohn for purposes of demonstration in the Hospital of the Rockefeller Institute, in order to make more clear the discussion of lesions of the conducting system. The idea of carrying out such injections came from a conversation with Dr. MacCallum, in which the latter stated incidentally that he had seen hearts at Stanford University with conduction system injected. Dr. Cohn at this time was no longer a member of Dr. MacCallum's staff, having been appointed associate in medicine in the Hospital of the Rockefeller Institute. Dr. MacCallum told Dr. Cohn nothing of the details of the method, nor did Dr. Cohn have any communication with Dr. Oppenheimer on the subject, but he experimented quite independently, and, after trying various dyes, finally succeeded in preparing some beautiful specimens, using India ink for the purpose. In his demonstration of these specimens before the staff of the hospital at our weekly meeting, Dr. Cohn made no claim, and made no attempt to lead the staff to infer, that he was the first to discover that such injections might be made, or that he was the discoverer of a method of making such injections. Indeed, all the members of the staff, including myself, fully understood otherwise. Dr. Cohn did not state who had first made such injections, however. Indeed, as he tells me, at that time he did not know the name of the person who had done so.

The injected hearts were so beautiful and instructive that at a meeting of the Pathological Society, occurring shortly after they were made, he demonstrated them to the members present. At this meeting no attempt was made to claim credit for the method. Indeed such a claim would have been preposterous, since Dr. MacCallum, the president of the society, had himself told Dr. Cohn of seeing such injections in California. So far as can be learned, no one at the meeting of the Pathological Society was deceived by Dr. Cohn, and no attempt was made to deceive. The Proceedings of the Pathological Society which are published consist mainly of brief notes, in the form of abstracts of the remarks of those making demonstrations or reports. In the volume for 1911 appears such a report, one page in length, concerning Dr. Cohn's demonstration. Previous to the meeting Dr. Cohn had made no notes, and his demonstration was entirely informal. This demonstration by Dr. Cohn was in no way considered as a publication. No effort had been made to find any literature concerning this subject, and the demonstration was not given with any idea of establishing priority, or indeed of obtaining any credit for discovery of a new method. It is quite true that Dr. Lhamon's name was not mentioned at this demonstration, and his name does not appear in the note published in the Transactions. This is indeed unfortunate and if it has led, or were likely to lead, to any misunderstanding, I am

sure that Dr. Cohn and all concerned would regret it exceedingly.

Dr. Lhamon's paper describing the method appeared in the *American Journal of Anatomy* for March, 1912, and Dr. Cohn's publication did not appear until May, 1913 (*Heart,* 1913, iv, 225). Dr. Cohn's paper dealt with the subject in a different manner from Dr. Lhamon's, and did not purport to be the description of a new method. In this paper Dr. Cohn expressly states how he learned that such injections were possible, and gives a reference to Dr. Lhamon's communication. It hardly seems, therefore, that Dr. Meyer has any serious ground for complaint or cause for worry. If any doubts remain in his mind, he should be reassured by the fact that in the monograph by Aagaard and Hall, "Ueber Injektionen des 'Reizleitungssystems' und der Lymphgefässe des Säugetierherzens" (Wiesbaden, 1914), priority is given to Lhamon, although they were familiar with Cohn's paper in which reference is made to the report in the New York Pathological Society Transactions.

RUFUS COLE
HOSPITAL OF THE ROCKEFELLER INSTITUTE,
November 16, 1915

SCIENTIFIC BOOKS

Methods in Plant Histology. By CHARLES J. CHAMBERLAIN, professor of botany in the University of Chicago. University of Chicago Press, 1915. Price $2.25.

When a work like the present has reached its third edition there can be no question as to its value for the public to which it appeals. It begins with an account of apparatus, including some valuable improvements which have originated in the botanical laboratories of the University of Chicago. There follow chapters on reagents, stains and staining, microchemical tests, free-hand sections, the glycerin method, the Venetian turpentine method, the paraffine method, the celloidin method, special methods and photomicrographs and lantern slides. The last two chapters contain the chief novelties of the edition and one can only say of them that they are excellent but might with advantage be much fuller. One wonders, however, why slow contrast plates are used for the photomicrographs instead of more rapid iso- or chromatic plates, which would give better results in much less time.

The second part of the treatise, covering more than half its total number of pages, is devoted to the specific directions for securing and studying representatives of the various groups of lower and higher plants. This section of the work will appeal specially to those taking extension courses and to teachers, whose acquaintance with laboratory methods is not recent. Following the specific directions for the study of the larger groups of plants are final chapters on the use of the microscope, labelling and cataloguing preparations, class list of preparations and formulæ for reagents. Last of all the book closes with a good index. It is copiously illustrated often by means of excellent photomicrograms. The best that can be said of this work is that it will do for the American student of botany, what Strasburger's "Botanische Practicum" has done for those of all lands. Like the "Practicum" of the great German morphologist it has passed through a number of editions, an unquestionable tribute to its value. E. C. JEFFREY

W. I. Palladin, Pflanzenanatomie, nach der fuenften russischen Auflage uebersetzt and bearbeitet. VON S. TSCHULOK. Leipzig u. Berlin, B. G. Teubner, 1914.

This work on anatomy by one of the professors of botany in the University of St. Petersburg (Petrograd) is essentially the so-called physiological plant-anatomy of Haberlandt, tempered with a large infusion of the morphology of Strasburger. It is a curious phenomenon to find German ideas thrown into the form of a book and illustrated with figures of German origin by a Russian botanist, translated back into the Teutonic speech for German consumption. The loss in this peculiar sort of metempsychosis is much less than one would suspect but the advantage of it is difficult to imagine. The work in question is chiefly valuable, not because it presents any new points of view or is illustrated by any new figures, but because it presents a clear and readable résumé

of the subject from the point of view of physiological plant anatomy. That point of view is for the present, however, somewhat under a cloud in this country because it does not appeal to the morphologist and the evolutionist on the one hand or to the cultivator of the disembodied plant physiology at present in vogue in these United States, on the other. When the physiologist among us again begins to recognize the importance of plant structures, he will possibly find a work conceived in this manner useful.

E. C. Jeffrey

America's Greatest Problem: the Negro. By R. W. Shufeldt, M.D., major, medical corps, United States Army, member Association of American Anatomists, fellow of the American Ornithologists' Union, etc. Philadelphia, 1915. Roy. 8vo, pp. 377, with fifty-two illustrations.

Unfortunately this volume has been heralded as "a wonderfully startling book . . . certain to instantly arouse a vigorous nation-wide discussion," and—by implication—as "an authoritative . . . guide to the solution of this menace of the deterioration of the Caucasian race in America." Nevertheless (these hyperboles being credited to the mercantile enthusiasm of the publishers, whose part has been done quickly and well), a notice of it was undertaken by the present writer partly because of his interest in the Negro, and partly because he took for granted that the author, a well-known ornithologist and comparative anatomist, would materially increase our knowledge of the facts involved, facilitate our comprehension of the nature and causes of the existing undesirable relations between the races, and offer something novel as "a remedy whereby the peril may be safely passed."

These expectatons have not been met. On the contrary, while the author's earnestness is evident, a careful and unprejudiced examination of the volume leads the reviewer to wish that the time and energy expended upon it had been devoted to the strictly scientific work which the author had in hand (p. vii); that might, at least, have been free from the needlessly frequent references to topics connected with *psychopathia sexualis* which characterize this and some of his other publications.

Burt G. Wilder

SPECIAL ARTICLES

ZYGOSPORES AND RHIZOPUS FOR CLASS USE

Rhizopus nigricans—the common bread mold—is the form most frequently used in the microscopic study of fungi in elementary classes in botany. Its production of both sexual and non-sexual spores, added to the ease with which it may be obtained and grown without refined laboratory facilities, makes it an ideal form for class study. The zygospores, though not difficult to find, have been overlooked by most teachers and many requests have been made of the writer for information in regard to methods of obtaining them. It has seemed desirable therefore to publish a short note on the subject.

Rhizopus is commonly found in nature on decaying fruits and vegetables as well as upon bread which has been kept in a moist atmosphere. The air is so full of its spores that almost any substratum rich in carbohydrates, if kept under proper moisture conditions, will produce a spontaneous growth of the fungus. The essential precaution is to insure a moist atmosphere and at the same time to prevent the substratum itself from becoming so moist as to stimulate the growth of bacteria. A simple method is to line a tumbler with moistened filter paper or even newspaper and to place a piece of bread on some non-absorptive object inside that will keep it from contact with the moist paper on the sides and bottom. The bread should be moist but not wet—the consistency of fresh bread is ideal—and the container should be kept closed. A bell jar lined with moist filter paper covering a dish with water or moist paper on the bottom, also makes a good moist chamber. Within a week, if the air has been kept moist, a good growth of the mold will result. Green molds will often be present as well, but the *Rhizopus* is so rapid in growth that contamination with other forms will not generally be seriously troublesome. Zygospores will sometimes be

found in the lower and moister parts of the culture below the sporangial growth but need never be expected in the upper and dryer regions. They frequently form in pure masses free from sporangia in the folds of crumpled paper directly below the substratum. The species, however, is diecious and it may frequently happen that the spores of only one of the two sexes, which together are necessary for zygospore production, have fallen upon the substratum. The chances of finding zygospores in the lower parts of a spontaneous culture will be increased if bits of the fungus from different sources in the field are laid on the bread when the culture is started. The two sexes are often found growing together in nature although the moisture conditions may not be such as to cause the appearance of zygospores. Thus, out of seven mixed transfers made this last month from as many individual decayed squashes in the field, three showed the presence of the two sexual races by production of zygospores, and of the remainder one was male and three were female. If even a small mass of zygospores is found, their production can be increased by laying on a fresh culture of bread, a bit of such zygosporic material freed as much as possible from sporangial spores. When an abundant production of zygospores has been once secured, the bread with the fungus growing on it can be dried and kept six months or more to be used later as "spawn" if broken up and laid on fresh bread when a zygosporic culture is again desired. Cultures have been kept over a year in this way but the spores are relatively short lived and fresh "spawn" should be prepared at more frequent intervals.

Zygospores of *Sporodinia* also may be readily obtained from sowings of the spores on bread in moist chambers. This mold is hermaphroditic. If a large collection of different fleshy fungi are left for a few days under a bell jar, a sporangial growth of *Sporodinia* will usually be found appearing on some of the decaying fungi.

In studying the habit of growth of the bread mold, pieces of paper on which the mold has spread will be found convenient or masses of the mold-infected bread (about half the size of an English walnut) which is beginning to show sporangia may be left for 24 to 48 hours in Petri dishes. If the Petri dishes are kept in too moist an atmosphere, stolons with but scanty sporongia may result, if kept too dry no stolons will be produced. If the Petri dishes be wrapped in paper, the proper conditions are generally secured. The presence of the columella within the unopened sporangium may be shown by drawing a solution of KOH under the cover.

To observe the swelling and germination of the sporangial spores, they may be sown in suitable fluid media or on nutrient agar. The filtrate obtained after boiling a couple of prunes for five or ten minutes in 100 c.c. of water makes a convenient fluid for the purpose without the necessity of further sterilization. Only enough spores should be added to make the fluid slightly clouded or to give a sufficient number of germinations in a drop taken for observation. At room temperature the formation of germ tubes may be expected in five or six hours. The process may be hastened or delayed by keeping the spores at higher or lower temperatures.

The methods suggested in the preceding paragraphs have been purposely such as can be adopted by any teacher without the facilities for sterilization. It will not be necessary to give detailed directions to those familiar with cultural methods. It may be said, however, that *Rhizopus* and especially its zygospores develop best upon nutrients rich in carbohydrates. If agar is used, 4 per cent. to 8 per cent. dextrose will be found a desirable ingredient of any formula. Bread is an ideal substratum but ordinary sterilization renders it pasty and unfit for use. A short sterilization with steam, but not under pressure, continued for less than five minutes will probably be found satisfactory.

The two sexes may be isolated from a culture, producing zygospores by making transfers from individual sporangia to well-separated points in the outer margin of a large dish of some suitable substratum. Zygospores will appear between the growths of oppo-

site sexes. Since one of the sexes may predominate in sporangial growth, the writer has found it a surer method to pick out with fine needles young zygospores free from sporangial spores and to plant them in Petri dishes on nutrient agar. One or both suspensors are likely to grow into mycelia which can be tested out as suggested above.

Inoculation of many sporangial spores causes a dense growth of small sporangia and a reduction of the mycelial growth at the point of inoculation. It is therefore advisable to inoculate only a small number of spores when desiring zygospore production or better yet, to make transfers of the mycelia from fresh tubes of the fungus before they have produced sporangia. In either way the opposite sexes may be sown together or slightly separated so as to cause a somewhat indefinite mass of zygospores where the opposing growths meet. If the nutrient requirements are satisfied and the atmosphere is kept saturated, zygospores may be thus obtained in abundance and nearly free from sporangia.

To teachers on my regular exchange list I am planning to send out dried male and female spore material of *Rhizopus* for use with their classes, together with reprints of the present article. I should also be glad to supply any other teachers with this material who may request it. Cultures should be started from this dried material within a month's time. The male and female cultures may be kept running by transfers to fresh nutrient about every three or four months.

A. F. Blakeslee

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Notes on the Factors Involved in the Germicidal Effect of Freezing and Low Temperatures

Many interpretations and conclusions on the germicidal activity of low temperatures and freezing have been given by earlier investigators. Cold was formerly considered a powerful disinfecting agent, but now there is a tendency to emphasize other factors than cold itself as potent. In fact we know that cold may act as a preserver of germ life, as the high bacterial content of frozen food stuffs after weeks and months of refrigeration indicates. Ice, on the other hand, tends to purify itself upon storage.

There are numerous variables which may have an important bearing upon the experiments. A partial list of these includes: (1) The species or strain of bacteria used, (2) the history and cultural manipulation of the organism prior to freezing, (3) the physical and chemical composition of the medium in which the organism is frozen, (4) the temperature of the frozen mixture, (5) the duration of the freezing, (6) the abruptness of temperature changes, (7) the cultivation of the organism subsequent to freezing. This list includes those factors which we took special pains to control.

The bacteria may be killed by the mere fact of low temperature interfering with metabolism; by freezing of the cell contents and rupture of the membrane by internal pressure; by external pressure or grinding developed during crystallization, or by expansion of the frozen medium within the receptacle; or by more or less prolonged suspension of metabolic activities, leading to slow death from old age or starvation.

We shall not take the space to give more than a summary of our preliminary results.

I. The comparative germicidal potency of freezing on different species and strains of bacteria.

B. coli and *B. subtilis* (twenty-four hour old cultures, the latter presumably practically spore-free), showed the former species to be much more susceptible to freezing. Ninety-nine per cent. and over of the *B. coli* succumbed to freezing in tap water in three hours, while with *B. subtilis* the reduction was not at all uniform, but seldom exceeded eighty per cent. Three strains of *B. coli* tested showed no appreciable variability in relation to the disinfecting influence of cold and freezing.[1]

[1] The remainder of our experiments were performed with *B. coli*.

II. The influence of intermittent freezing and thawing upon *B. coli.*

If crystallization is in some way effective in destroying germ life, then alternate freezing and thawing should bring about a greater reduction than prolonged freezing. Table I. shows a part of one of our protocols. It will be noted that intermittent freezing has but slightly greater germicidal value than has sustained freezing for the same period of time.

III. The effect of the degree of cold used in the freezing mixture.

Tubes containing the bacteria were frozen and held for three hours for comparison at approximately —15 degrees C. and —2 degrees C. The colder temperature was considerably more fatal. Tubes kept at +.5 degree C., used as controls in most of the experiments, showed marked variation, but seldom showed over 30 per cent. to 40 per cent. of the bacteria to be killed.

IV. The composition of the media and its influence upon germ survival in freezing mixtures.

It was with the object of studying this feature of the work that we began our experiments. They are still very deficient, but what we have found is worthy of consideration.

Distilled water and Boston tap water give very uniform and comparable results.

Using cream containing 30 per cent. of butter fat, we found very striking protection afforded the bacteria when frozen, whether the freezing be continuous or intermittent. Held at just above the freezing temperature, we find about the same percentage reduction to occur as in water, though the results are very erratic, occasionally showing an increase during the course of a few hours. Freezing and thawing at intervals is considerably more fatal than continuous freezing. A few typical results of freezing *B. coli* in cream are given in the second table.

It is premature to suggest conclusions but our results lead us to infer that the degree of cold, time of freezing, crystallization and external pressure, and the composition of the media in which the freezing occurs all have an influence upon the germicidal potency exhibited by cold. Probably all of the explanations for the mode of destruction, suggested in the early part of these notes, must be considered as important.

TABLE I

A Comparison of the Percentage Reduction of B. coli held at .5° C., —15° C., and Frozen Intermittently for a Three-hour Period

Initial Count	First Freezing	Second Freezing	Third Freezing	Fourth Freezing	Freezing 3 Hours	Cold 3 Hours
2130	82.2%	99.9%	99.9%	99.9%	99.9%	23.0%
1670	92.8	96.1	99.8	99.9	99.7	29.0
1320	93.8	98.7	99.9	99.9	99.4	47.0
3015	97.6	99.6	99.5	99.9	99.8	31.3
4800	98.6	99.4	99.8	99.8	99.8	32.0
1370	98.6	99.5	99.8	99.9	99.7	8.1
1070	97.9	99.5	99.5	99.9	99.9	97.3

TABLE II

Percentage Reduction Obtained with B. coli in Cream at Freezing Temperatures

Initial Count	First Freezing	Second Freezing	Third Freezing	Fourth Freezing	Freezing 3 Hrs. 0° C.	Cold 3 Hrs. .5° C.
4350	4.8%	39.3%	45. %	48.9%	61.3%	18.6%
4740	40.5	45.5	71.5	75.9	67.7	42.7
5275	43.1	46.7	71.9	81.2	44.2	16.4
5284	33.4	48.2	60.2	—	26.4	20.8
5028	32.2	36.2	48.4	71.7	34.8	20.6
3732	35.2	20.9	42.3	50.1	33.6	38.9
4030	71.0	67.1	78.6	83.1	67.6	3.9
5085	21.1	51.6	53.3	75.4	65.3	23.8
4725	16.1	36.5	52.2	72.6	58.0	16.8
4560	34.8	47.1	67.4	63.8	54.2	19.7

C. M. HILLIARD,
CHRISTINA TOROSSIAN,
RUTH P. STONE

SIMMONS COLLEGE

SOCIETIES AND ACADEMIES

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE—SECTION OF EDUCATION

THE special summer session of Section L, Education, of the American Association for the Advancement of Science met at the University of California on Tuesday, August 3, and at Stanford University on the following day. The morning meeting on Tuesday was a joint meeting with

Section H and the American Psychological Association. The general subject of the Section's meetings was, "The Scientific Study of Educational Problems."

The joint meeting on Tuesday has already been reported by Dr. J. E. Coover for the American Psychological Association,[1] and need not be reviewed here again. It is worth while noting, however, that the papers all dealt with the application of psychological tests to various groups of individuals. Drs. Grace M. Fernald and Olga L. Bridgman were interested in delinquents; Professor Louis N. Terman in extending the Binet tests; Professor Kate Brousseaux in the feeble-minded; Mrs. V. C. Hicks and Dr. J. E. W. Wallin in mental defectives in the schools; Professor Eleanor Rowland in intelligence tests for college students, and Mr. LeRoy W. Fike in tests for stenographers.

In the afternoon President Wm. T. Foster reported the system of scientific grading in operation at Reed College and explained how credit was awarded for varying grades of quality in the work of the students. Mr. Chas T. Luthy, of Peoria, Ill., reported in considerable detail the mechanism of human speech sound and urged that greater attention be paid this subject, especially on the part of primary and language teachers, so that they might more intelligently understand the mistakes made by their pupils and know how to correct them. The paper by Mr. Walter B. Swift, of Boston, on the "Management of the Speech Defect Problem in the Public Schools" was read by Professor Terman. The acting-secretary read the paper of Mr. Wm. Kent, of Montclair, N. J., on "Elements in the Teaching of Writing." In this paper the writer calls attention to the fact that the difficulty in learning to write is as much due to lack of training of the eye to see errors as it is to lack of ability in executing movements with the hand. He suggested a number of simple exercises by which the eye might be trained in noting defects and in guiding simple movements of the hand before actual practise in writing commenced. Professor Paul H. Hanus's paper, "Measuring Progress in Latin" was also read by the acting-secretary. His paper was a preliminary report on the development of three tests which might indicate progress in Latin. These tests covered vocabulary, grammar and translation. The general scheme was to prepare such tests as might be applied to first-year students and then to have them given in each of the four high-school years. Mr. Wilford E. Talbert called attention in his paper on the "Principal's Study Club of Oakland, Calif.," to what could be done in the way of cooperative research work in a public-school system—Dr. Sears's work, reported below, being mentioned as one example. The program for the day was completed by a paper on "The Vitalizing Principle in Education," by Professor Edward J. Kunze, of the Oakland Agricultural and Mechanical College.

After a very enjoyable morning spent in visiting Stanford University where all were most hospitably entertained, the Section held its concluding session on Wednesday afternoon. Dr. L. W. Sackett, of the University of Texas, presented a very interesting paper on "Measuring a School System by the Buckingham Spelling Scale" in which he showed objectively each school system's standing in spelling—also the standing of each department and grade of each school system. Dr. L. B. Sears, of Stanford University, reported on the "Spelling Efficiency in the Oakland Schools." His general conclusion was that there was no standardization at all. Professor L. Edgar Coover called attention to several of the technical difficulties which still confuse the whole problem of "Formal Discipline." Professor Edward K. Strong, Jr., of George Peabody College for Teachers, reported on several cases in which special instruction had been given fourth-grade children in arithmetic with the result that the children had gained noticeably not only in arithmetic but in other subjects—the gain being due to changes in the child's attitude toward himself. It was suggested that learning curves in arithmetic be employed for this particular purpose. Dr. David S. Hill's paper was a "Survey of Industries in Mechanical Occupations in New Orleans by the Division of Educational Research." Several points were presented dealing with the relationship between occupational needs and industrial and vocational education. He also reported on the work being done in New Orleans in handling the defective child. Mr. Geo. E. Hall, describing an interesting study being made in the Schenectady high schools on "High-school Non-Promotions and Some Factors that Affect them," brought out the point that non-promotion is due not only to incapacity but in many cases to outside interests such as society, clubs or the need to earn money.

Edward K. Strong, Jr.,
Acting-Secretary, Section L

[1] J. E. Coover, Report of Secretary of Committee on Program for San Francisco meeting of the American Psychological Association, *Psychol. Bull.*, September, 1915, 12, 313–332.